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Proposed Re-evaluation Decision

PRVD2010-18

Malathion

(publié aussi en français)

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Overview

Proposed Re-evaluation Decision for Malathion

After a thorough re-evaluation of the insecticide malathion, Health Canada's Pest Management Regulatory Agency (PMRA), under the authority of the *Pest Control Products Act*, is proposing continued registration of products containing malathion for sale and use in Canada. An evaluation of available scientific information found that, under the proposed conditions of use:

- Most uses of malathion products have value in Canada and do not pose unacceptable risks to human health or the environment, that is, commercial products applied in agricultural (such as food and non-food crops in greenhouse or fields, livestock for food) and non-agricultural settings (such as structural, human habitat and recreational areas), other than those noted below. As a condition of the continued registration for these malathion uses, new risk reduction measures are proposed. Additional data are being requested.
- Some uses of malathion are proposed for phase-out because they are not supported by the technical registrant. These uses were not included in the risk assessment:
 - ° Aquatic non-food sites: mosquito breeding areas and standing water;
 - ° Greenhouse food crops: mushroom beds and houses (wetable powder and dust formulations and application method of painting on wooden surfaces);
 - ° Greenhouse non-food crops: carnation, chrysanthemum, geranium, rose, snap dragon and ornamental plants (wetable powder formulation and fogging application method);
 - ° Seed treatments food and feed and seed treatment non-food: seeds (field and garden);
 - ° Terrestrial feed crops: ground ULV for alfalfa;
 - ° Structural: bakeries, canneries, meat processing plants, barns, pig pens, outbuildings, dairies, dairy barns, dwelling foundations (indoor), farm buildings (indoor), food processing plants, poultry houses and shipping crates;
 - ° Human habitat and recreational areas: farm yards, pens, feedlots, pastures, stabling areas, manure piles, garbage areas and around buildings and undergrowth to control house fly, mosquitoes, stable fly, and small flying insects as a space spray, mist, fog, aerosol and ground ULV;
 - ° Municipal dumps, refuse areas, sewage lines; and
 - ° Residential outdoors: yards.

The PMRA's pesticide re-evaluation program considers potential risks as well as the value of pesticide products to ensure they meet modern standards established to protect human health and the environment. In 1999, Health Canada announced in Re-evaluation Note REV99-01, *Re-evaluation of Organophosphate Pesticides*, that 27 organophosphate active ingredients, including malathion, would be re-evaluated in Canada. This re-evaluation draws on data from registrants, published scientific reports, information from other regulatory agencies and any other relevant information available.

In 2003, the PMRA published a proposed re-evaluation consultation document (PACR2003-10) for malathion use as an adulticide in mosquito abatement programs, and followed with a document (REV2003-03) which described the mitigation measures to be implemented for malathion use as an adulticide. The required label changes for related end-use products have been implemented as described in REV2003-03. The PMRA received comments following the release of PACR2003-10. These comments were considered and the PMRA's response to these comments are summarized in Appendix XXIII.

The technical registrant of malathion in Canada, Cheminova Inc., has voluntarily discontinued a number of residential uses including structural (pet quarters, indoor uses); companion animals (pet treatment); turf (broadcast turf/lawn treatment); and residential outdoors (broadcast/turf lawn treatment). The changes to the related product labels have been completed.

As discussed in this document, the PMRA has completed the risk and value assessments for malathion on the remaining food and non-food uses. All relevant end-use products containing malathion registered in Canada are affected by this proposal. Once the final re-evaluation decision is made, registrants will be instructed on how to address any new requirements.

This Proposed Re-evaluation Decision is a consultation document¹ that summarizes the science evaluation for malathion and presents the reasons for the proposed re-evaluation decision. It also proposes additional risk-reduction measures to further protect human health and the environment.

The information is presented in two parts. The Overview describes the regulatory process and key points of the evaluation, while the Science Evaluation provides detailed technical information on the human health, environmental and value assessment of malathion.

The PMRA will accept written comments on this proposal up to 60 days from the date of publication of this document. Please forward all comments to Publications (please see contact information on the cover page of this document).

¹ "Consultation statement" as required by subsection 28(2) of the *Pest Control Products Act*.

What Does Health Canada Consider When Making a Re-evaluation Decision?

The key objective of the *Pest Control Products Act* is to prevent unacceptable risks to people and the environment from the use of pest control products. Health or environmental risk is considered acceptable if there is reasonable certainty that no harm to human health, future generations or the environment will result from use or exposure to the product under its conditions or proposed conditions of registration.² The Act also requires that products have value³ when used according to the label directions. Conditions of registration may include special precautionary measures on the product label to further reduce risk.

To reach its decisions, the PMRA applies hazard and risk assessment methods as well as policies that are rigorous and modern. These methods consider the unique characteristics of sensitive subpopulations in both humans (for example, children) and organisms in the environment (for example, those most sensitive to environmental contaminants). These methods and policies also consider the nature of the effects observed and the uncertainties present when predicting the impact of pesticides. For more information on how the PMRA regulates pesticides, the assessment process and risk-reduction programs, please visit the Pesticides and Pest Management portion of Health Canada's website at healthcanada.gc.ca/pmra.

Before making a re-evaluation decision on malathion, the PMRA will consider all comments received from the public in response to this consultation document.⁴ The PMRA will then publish a Re-evaluation Decision⁵ on malathion, which will include the decision, the reasons for it, a summary of comments received on the proposed registration decision and the PMRA's response to these comments.

For more details on the information presented in this overview, please refer to the Science Evaluation section of this consultation document.

What is Malathion?

Malathion is a group 1B Resistance Management Mode of Action (MoA) non-systemic, broad-spectrum organophosphate insecticide and acaricide. It disrupts nervous system function by inhibiting the acetylcholinesterase enzyme. It is used to control a broad range of insect pests on a wide variety of sites including: aquatic non-food sites; empty food storage areas; greenhouse (food and non-food crops); human habitat and recreational areas; industrial oilseed and fibre

² "Acceptable risks" as defined by subsection 2(2) of the *Pest Control Products Act*.

³ "Value" as defined by subsection 2(1) of the *Pest Control Products Act*: "the product's actual or potential contribution to pest management, taking into account its conditions or proposed conditions of registration, and includes the product's (a) efficacy; (b) effect on host organisms in connection with which it is intended to be used; and (c) health, safety and environmental benefits and social and economic impact".

⁴ "Consultation statement" as required by subsection 28(2) of the *Pest Control Products Act*.

⁵ "Decision statement" as required by subsection 28(5) of the *Pest Control Products Act*.

crops; livestock for food; seed treatment; stored food and feed; structural sites; terrestrial feed and food crops; outdoor ornamentals; and residential outdoor sites.

It is applied using conventional ground and aerial application equipment by farmers, farm workers, professional applicators and the general public.

Health Considerations

Can Approved Uses of Malathion Affect Human Health?

Additional risk-reduction measures are required on malathion labels. Malathion is unlikely to affect your health when used according to the revised label directions.

Potential exposure to malathion may occur through the diet (food and water) or when handling and applying the product. When assessing health risks, two key factors are considered: the levels where no health effects occur in animal testing and the levels to which people may be exposed. The dose levels used to assess risks are established to protect the most sensitive human population (for example, children and nursing mothers). Only uses for which the exposure is well below levels that cause no effects in animal testing are considered acceptable for registration.

Toxicology studies in laboratory animals describe potential health effects from varying levels of exposure to a chemical and identify the dose where no effects are observed. The health effects noted in animals occur at doses more than 100-times higher (and often much higher) than levels to which humans are normally exposed when malathion products are used according to label directions.

The target for malathion is the nervous system including effects on neurobehavioural parameters and acetylcholinesterase, an enzyme necessary for normal functioning of the nervous system. Overexposure may produce a variety of symptoms in animals and humans including nausea, dizziness, sweating, salivation, runny nose and watery eyes. This may progress to muscle twitching, weakness, tremor, incoordination, vomiting, abdominal cramps and diarrhea in more serious poisonings. Cholinesterase inhibition has been observed with oral, dermal and inhalation exposure. Young animals have been shown to be more sensitive to this effect of malathion.

Malathion was not found to be genotoxic or teratogenic. Based on the scientific evidence, malathion is unlikely to pose a carcinogenic risk for humans. Following administration to pregnant rabbits, an increase in resorptions (embryo-fetal loss) has been observed in the presence of maternal toxicity. Due to the nature of this endpoint and its potential implications on the health of the unborn child, extra protective measures were applied during the risk assessment to further reduce the allowable level of human exposure to malathion. The risk assessment protects against these effects by ensuring that the level of human exposure is well below the lowest dose at which these effects occurred in animal tests.

Residues in Water and Food

Dietary risks from food and water are not of concern

In its evaluation of risk from the exposure of malathion and malaoxon, the PMRA has adopted protective and conservative estimates of residues to compensate for the high potency factor of the malaoxon metabolite in food and water and for data gaps. In particular, the PMRA has compensated for malaoxon residues that were, for the most part, below analytical detection.

The PMRA has also considered the special case of exposure arising from on-site consumption during Pick-Your-Own operations.

Reference doses define levels to which an individual can be exposed over a single day (acute) or lifetime (chronic) and expect no adverse health effects. Generally, dietary exposure from food and water is acceptable if it is less than 100% of the acute reference dose or chronic reference dose (acceptable daily intake). An acceptable daily intake is an estimate of the level of daily exposure to a pesticide residue that, over a lifetime, is believed to have no significant harmful effects.

Acute dietary risk for children and infants was the highest and reached 101% of reference dose, but is considered below the level of concern due to the conservative assumptions. Chronic risk for children reached 66% of reference dose and is not of concern.

Dietary exposure from Pick-Your-Own operations were estimated by adding the acute exposure from all forms of fresh fruit to the chronic exposure, in this case, apple and strawberry. Calculated MOEs exceed the target MOE for all sub-populations, and are not of concern.

Overall, the PMRA has concluded that risk to health from dietary residues is not of concern.

Risks in Residential and Other Non-Occupational Environments

Residential risks from the use of malathion on vegetable gardens, ornamentals, and in mosquito abatement programs are not of concern.

Malathion is registered for use on residential ornamental and vegetable gardens, and on exterior wall surfaces, around foundations, under fences and shrubs, and around buildings. Malathion is also registered for use in mosquito abatement programs, where bystanders could potentially be exposed by the inhalation route or by being exposed to malathion residues on turf. Estimates of exposure reach the target Margin of Exposure (MOE) for adults and children for all application exposure scenarios and most post-application, and are therefore not of concern.

Residential risks from potential exposure to malaoxon on decks and playstructures are not of concern.

Malaoxon is a degradation product of malathion, which forms on hard surfaces such as decks and playstructures. Estimates of exposure for children, adolescents, and adults using default assumptions and chemical-specific monitoring data reach the target MOE, and are therefore not of concern.

Aggregate risk from exposure incurred at "Pick Your Own" orchard or berry facility is not of concern.

"Pick Your Own (PYO)" facilities are considered commercial farming operations that allow public access for harvesting in large-scale fields or orchards treated with commercially labelled malathion products. Estimates of exposure that aggregate the dermal exposure incurred during harvest and the dietary exposure from consuming fresh fruit reach the target MOE for orchard and berry crops, and are therefore, not of concern.

Occupational Risks from Handling Malathion

Occupational (mixer/loader/applicator) risks are not of concern when products are used according to revised label directions.

Most occupational risks due to malathion are not of concern for agricultural scenarios. Based on the precautions and directions for use on current labels, risk estimates associated with certain, mixing, loading and applying activities reach target MOEs, and are not of concern. For those uses that do not reach the targeted MOEs, mitigation measures such as additional personal protective equipment, engineering controls, or restrictions on amount handled per day are required to reduce potential exposure and protect worker's health.

Occupational postapplication risks are not of concern.

Postapplication occupational risk assessments consider exposures to workers entering treated sites in agriculture. Most occupational postapplication risks are not of concern if proposed protective measures are followed. When the proposed mitigation measures such as lengthened restricted entry intervals (REIs) are considered, the risk estimates for postapplication workers meet the target MOE, and are not of concern.

Environmental Considerations

What Happens When Malathion is Introduced Into the Environment?

Malathion poses a potential risk to terrestrial and aquatic organisms, therefore additional risk reduction measures need to be observed.

When malathion is released into the environment some of it can be found in soil and surface water. Malathion is very soluble in water and does not adsorb strongly to soils and therefore may leach into groundwater and enter surface water in runoff. Water monitoring has revealed malathion residues in groundwater as well as surface water, albeit infrequently and at low concentrations.

Malathion breaks down into several transformation products through hydrolysis and biotransformation at rates that depend on environmental conditions. The major transformation products, identified in biotransformation studies (mono- and dicarboxylic acid of malathion, demethyl mono and di-carboxylic acid of malathion), are expected to be non-persistent in the environment. Malaoxon, the oxidation transformation product that is primarily responsible for the toxicity of malathion, is also expected to be non-persistent. Under neutral and alkaline conditions, both malathion and malaoxon readily hydrolyse and are increasingly stable under acidic conditions. In soil, malathion is not expected to phototransform, but may photolyze in natural waters containing photosensitizing agents. Malathion is not expected to volatilize significantly and is demonstrated to have low potential for bioaccumulation in fish.

Malathion poses a risk to both terrestrial and aquatic organisms. Birds are at risk in and around the site of application due to the consumption of contaminated food items, and the risk cannot be mitigated. In order to minimize the potential exposure to aquatic organisms, strips of land between the agricultural field and the aquatic areas (buffer zones) will be left unsprayed. The width of these buffer zones will be specified on the product label.

Value Considerations

What is the Value of Malathion?

Malathion is registered for use on a broad spectrum of sites for the control of a wide range of pests.

In Canada, malathion is registered to control a broad range of pests including beetles, bugs, butterflies, crickets, earwigs, flies (including black flies, face and horn flies and mosquitoes), grasshoppers, lice, mites, moths, spiders, thrips and ticks on a wide variety of sites.

Malathion for the control of a wide variety of chewing pests.

Malathion is a non-systemic insecticide and acaricide with contact, stomach, and respiratory action. Malathion is suited for control of a wide variety of chewing insects.

IPM compatibility and short pre-harvest interval

Malathion has short pre-harvest intervals (PHI). It is frequently used in berry production and is considered as IPM compatible.

User Requested Minor Use Label Expansions

Malathion has several uses that were registered through the User Requested Minor Use Label Expansion (URMULE) program. These uses have few viable alternative active ingredients or no registered alternatives.

Measures to Minimize Risk

Registered pesticide product labels include specific instructions for use. Directions include risk-reduction measures to protect human and environmental health. These directions are required by law to be followed.

Risk-reduction measures are being proposed to address potential risks identified in this assessment. These measures, in addition to those already identified on existing malathion product labels, are designed to further protect human health and the environment. The following key risk-reduction measures are being proposed.

Additional Key Risk-Reduction Measures

Human Health

To protect mixer/loader/applicators using commercial products:

- Additional personal protective equipment
- Restrictions on amount of active handled per day
- Packaging of all malathion wettable powder products in water soluble packaging

To protect workers entering treated sites, restricted entry intervals are to be implemented

To protect homeowners using domestic products:

- specification that the higher application rate of 30 g ai/L is to only be used for dwelling foundation applications

Environment

- Additional advisory statements to protect non-target terrestrial and aquatic organisms and to reduce the potential for malathion residues in runoff to adjacent aquatic habitats
- Buffer zones for aquatic habitats (the PMRA is seeking comments on the feasibility of the buffer zones proposed for aerial applications.)
- A statement advising that the use of malathion may result in contamination of groundwater, particularly in areas where soils are permeable and/or the depth to the water table is shallow.

What Additional Scientific Information is being Requested?

The human health risks and risks to the environment were found to be acceptable for most uses of malathion with the additional mitigation measures. However, additional information is being requested to help refine the risk assessments.

The following studies or suitable scientific rationale would be required to support continued registration as per section 12 of the *Pest Control Product Act*:

- Use Description - Qualitative information to more fully characterize exposure from grape vines (nursery), livestock, stored grain, structural uses, and mushroom houses.
- Post-application Worker - Passive Dosimetry or Biological Monitoring, and/or Dislodgeable/Transferable Residue - Data are needed to provide estimates of post-application worker exposure in mushroom houses.
- Post-application Worker - Passive Dosimetry or Biological Monitoring, and/or Dislodgeable/Transferable Residue - Data are needed to provide estimates of post-application worker exposure in structural sites (for example, flour mills).
- Dislodgeable/Transferable Residues - Residue studies that measure the formation and dissipation of malaoxon in airborne spray and, particularly, on deposited surfaces such as hard surfaces and turf over a 10- to 30- day period following application of ULV malathion.
- Residue data to confirm the assumptions made in the dietary risk assessment. In particular, metabolism and magnitude of residues resulting from direct application on livestock, and magnitude of residues from treating stored grain.
- Immunotoxicity study.

Next Steps

Before making a re-evaluation decision on malathion, the PMRA will consider all comments received from the public in response to this consultation document. In particular, the PMRA is seeking comments on the feasibility of some of the larger buffer zones proposed for aerial applications. In addition, the PMRA is looking for information related to Value, including:

- efficacy data or scientific rationale to show that the coarse droplet size sprays and other conditions used to obtain feasible buffer zones still result in adequate product performance.
- quantitative and/or qualitative data on the economic and social importance of malathion to specific industries.
- feedback on the viability of alternative chemical and non-chemical pest management practices for the registered site and pest combinations for malathion.

The PMRA will then publish a Re-evaluation Decision Document, which will include the decision, the reasons for it, a summary of comments received on the proposed decision and the PMRA's response to these comments.

Other Information

At the time that the re-evaluation decision is made, the PMRA will publish an Evaluation Report on malathion in the context of this re-evaluation decision (based on the Science Evaluation section of this consultation document). In addition, the test data on which the decision is based will also be available for public inspection, upon application, in the PMRA's Reading Room (located in Ottawa).

Once all organophosphate pesticides have been re-evaluated, a cumulative risk assessment will be conducted, which will consider potential exposure to all chemicals causing toxicity in the same manner. The results of the cumulative risk assessment may result in updates to any previous re-evaluation decision.

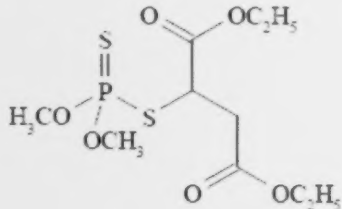
Science Evaluation

1.0 Introduction

Malathion is one of the organophosphate pesticides under re-evaluation in Canada as announced by the Pest Management Regulatory Agency (PMRA) in the June 1999 Re-evaluation Note REV99-01, Re-evaluation of Organophosphate Pesticides. Malathion is a non-systemic, broad-spectrum Resistance Management Group 1B (organophosphate) insecticide and acaricide which inhibits the enzyme acetylcholinesterase, interrupting the transmission of nerve impulses. It works by contact, ingestion and inhalation.

2.0 The Technical Grade Active Ingredient, Its Properties and Uses

2.1 Identity of the Technical Grade Active Ingredient

Common name	Malathion
Function	Insecticide
Chemical Family	Organophosphate
Chemical name	
1 International Union of Pure and Applied Chemistry (IUPAC)	Diethyl (dimethoxyphosphinothioylthio)succinate or <i>S</i> -1,2-bis(ethoxycarbonyl)ethyl <i>O,O</i> -dimethyl phosphorodithioate
2 Chemical Abstracts Service (CAS)	Diethyl [(dimethoxyphosphinothioyl)thio]butanedioate
CAS Registry Number	121-75-5
Molecular Formula	$C_{10}H_{19}O_6PS_2$
Structural Formula	

Molecular Weight	330.4
Purity of the Technical Grade Active Ingredient	96.5%
Registration Number	18150

Based on the manufacturing process used, impurities of human health or environmental concern as identified in the Canada Gazette, Part II, Vol. 142, No. 13, SI/2008-67 (2008-06-25), including TSMP Track 1 substances, are not expected to be present in the product.

2.2 Physical and Chemical Properties of the Technical Grade Active Ingredient

Property	Result
Vapour pressure at 30°C	5.3 mPa
Ultraviolet (UV)/visible spectrum	Not expected to absorb at $\lambda > 300$ nm
Solubility in water at 25°C	145 mg/L
n-Octanol/water partition coefficient	Log K_{ow} = 2.75
Dissociation constant	N/A

2.3 Description of Registered Malathion Uses

Appendix I lists all malathion products that are registered under the authority of the *Pest Control Products Act*, as of April 10, 2008. Appendix IIa lists all Commercial and Restricted Class uses for which malathion is presently registered, while Appendices IIb and IIc list all Domestic Class uses for which malathion is presently registered. Also presented in Appendix IIa is whether the use was added to the label through the PMRA Minor Use Program. While currently supported by the registrant, the data supporting the minor uses were originally generated by a user group.

The registrant is supporting the use of malathion on the following sites, which are included in the risk assessment:

- Empty food storage areas: bins and elevators, box cars, flour mill warehouses;
- Greenhouse food crops: lettuce and mushroom (EC formulation only);
- Greenhouse non-food crops: flowers (carnation, chrysanthemum, geranium, rose, snap dragon) and ornamental plants (EC foliar application only);
- Industrial oilseed crops and fibre crops: canola, flax, mustard;
- Livestock for food: beef and dairy cattle, goats (non-milking), poultry, sheep, swine;
- Stored food and feed: barley, corn, oats, rice, rye, wheat;
- Terrestrial feed crops: alfalfa, barley, clover, canary grass (for seed), corn (grain and forage), grasses and legumes grown for hay, non-agricultural land (wild host plants), pastures, rangeland, oats, sweet clover, wheat;

- Terrestrial food crops: apple (including crab apple), apricot, asparagus, barley, bean, beet (table), blackberry, blueberry, boysenberry, broccoli, Brussels sprouts, cabbage, canola (rapeseed), carrot, cauliflower, celery, cherry, collards, corn (grain), cranberry, cucumber, currant, dandelion, dewberry, eggplant, endive, flax, garlic, gooseberry, grape, horseradish, kale, kohlrabi, leek, lentil, lettuce, loganberry, melon, mustard, mustard (condiment type only), oats, onion (bulb and green), parsley, parsnip, pea, peach, pear, pepper, plum, potato, pumpkin, radish, raspberry, rutabaga, rye, salsify, shallot, spinach, squash, strawberry, sugar beet, swiss chard, tobacco, tomato, turnip, watercress, wheat, wild rice (cultivated);
- Structural: Dwelling foundations (outdoor foundations and spot perimeter treatment), flour mills, feed mills;
- Human Habitat and Recreational Areas: outdoor areas around buildings housing domestic animals, around yards, around processing plants and other buildings (baited spray to control house and stable flies);
- Ornamentals (outdoors): ornamentals; and
- Residential Outdoors: garden areas.

Certain uses are not supported by the registrant and, therefore were not included in the risk assessments:

- Aquatic non-food sites: mosquito breeding areas and standing water;
- Greenhouse food crops: mushroom beds and houses (wetable powder and dust formulations and application method of painting on wooden surfaces);
- Greenhouse non-food crops: carnation, chrysanthemum, geranium, rose, snap dragon and ornamental plants (wetable powder formulation and fogging application method);
- Seed treatments food and feed and seed treatment non-food: seeds (field and garden);
- Terrestrial feed crops: ground ULV for alfalfa;
- Structural: bakeries, canneries, meat processing plants, barns, pig pens, outbuildings, dairies, dairy barns, dwelling foundations (indoor), farm buildings (indoor), food processing plants, poultry houses and shipping crates;
- Human habitat and recreational areas: farm yards, pens, feedlots, pastures, stabling areas, manure piles, garbage areas and around buildings and undergrowth to control house fly, mosquitoes, stable fly, and small flying insects as a space spray, mist, fog, aerosol and ground ULV; municipal dumps, refuse areas, sewage lines; and
- Residential outdoors: yards.

3.0 Impact on Human and Animal Health

Toxicology studies in laboratory animals describe potential health effects resulting from various levels of exposure to a chemical and identify dose levels where no effects are observed. Unless there is evidence to the contrary, it is assumed that effects observed in animals are relevant to humans and that humans are more sensitive to effects of a chemical than the most sensitive animal species. The health effects noted here were observed in animals at dose levels at least 100-fold (often much higher) above levels to which humans are normally exposed through use of products containing this chemical.

3.1 Toxicology Summary

Hazard Identification

The current risk assessment is based primarily upon studies submitted by the registrant, although the hazard profile has been supplemented with data identified in international risk assessments and published journals (Appendix III).

Following oral administration to rats, malathion was rapidly absorbed and eliminated, mainly in the urine with lesser amounts excreted in the feces. Malathion is completely metabolized, with no parent compound detected in urine. It was determined that between 4% and 6% of the administered dose was converted to malaoxon, the active cholinesterase inhibiting metabolite of malathion. In addition to being a metabolite of concern in mammalian systems, malaoxon is also a known environmental degradate of malathion. The major metabolic pathway for both malathion and malaoxon is the hydrolysis of the carboxyester by tissue, liver or plasma carboxylesterases, resulting in the production of alpha and beta monocarboxylic acids. Greater than 80% of the radioactivity in urine was identified as the diacid (DCA) and monoacid (MCA) metabolites. Carboxylesterase is the major route of detoxification for both the parent and active metabolite, malaoxon. Malathion represents one of the few organophosphates that serve as a substrate for carboxylesterase. The carboxylesterase detoxification of malathion/malaoxon may be the reason for the decreased acute toxicity of malathion relative to other organophosphates.

Another proposed metabolic pathway involves the oxidative desulphuration of malathion by microsomal enzymes to malaoxon, which is excreted in the urine or further metabolised by phosphatases and carboxylesterase enzymes. Malaoxon, as with the oxons of other organophosphates, is also detoxified by arylesterase enzymes.

Malathion did not accumulate in tissues following single or multiple exposures in rats. There did not appear to be any dose-related or sex-related differences in the metabolism of malathion in rats.

Malathion exhibits low acute toxicity via the oral, dermal, and inhalation routes. Signs of acute toxicity were consistent with cholinesterase inhibition and included tremors, convulsions, salivation and dyspnea. Malaoxon is of high acute toxicity via the oral route. Malathion exhibits slight eye and mild dermal irritation in rabbits and is not a dermal sensitizer in guinea pigs under test conditions.

Isomalathion, an impurity in technical malathion, is of high acute oral toxicity and has been shown to potentiate the cholinesterase inhibiting effects of malathion. The toxicological assessment addresses the relative contribution of isomalathion to the overall hazard of malathion as toxicity studies were conducted with technical malathion. Stability data indicates that malathion is stable for up to a year at room temperature. Storage at temperatures above room temperature can lead to the production of increased concentrations of isomalathion and increased toxicity, consequently, label statements are required to ensure proper storage of the malathion products.

Like other organophosphorus pesticides, one mode of toxic action for malathion is the inhibition of plasma, erythrocyte and brain cholinesterase (ChE) activity. Dose-related inhibition of plasma, erythrocyte and brain cholinesterase activity occurs by all routes and durations of exposure to malathion. In repeat dose studies with malathion, plasma and erythrocyte cholinesterase inhibition were exhibited at various LOAELs following oral (mouse, rat, dog), inhalation (rat) and dermal (rabbit) exposure. For animals exposed to malathion, erythrocyte cholinesterase (EChE) is the most sensitive compartment for cholinesterase inhibition. While EChE inhibition itself is not considered an adverse effect, the PMRA considers EChE inhibition a suitable surrogate for peripheral neurotoxic effects. Brain cholinesterase inhibition typically occurred at higher doses in all species. Clinical signs typically associated with organophosphate exposure (including salivation, tremors, prostration and hypoactivity) have been observed in repeat-dose studies at doses of 150 mg/kg bw/day malathion and greater. The clinical signs occur at relatively higher doses with malathion compared to other organophosphates. In a developmental neurotoxicity assay, decreases in motor activity were observed in weanling females and flattened gait was observed in adult males at doses of 50 mg/kg bw/day and greater.

Neuropathological changes were not observed in the majority of mammalian toxicity studies. However, several isolated incidences of neuropathological changes have been observed in two rat studies at very high doses (> 1500 mg/kg bw/day) in only one sex (males) and are considered equivocal in nature. Points of departure used to establish standards in the current risk assessment are considered protective of any potential neuropathological effects.

Observed treatment-related effects including increases in liver, kidney and thyroid/parathyroid weights have been observed at 62.5 mg/kg bw/day and greater in rats and dogs following long-term oral exposure, with non-cholinergic hematological effects being observed at higher dose levels. An increase in severity of chronic progressive nephropathy has also been observed in rats of both sexes, with the females being affected at a lower dose (32 mg/kg bw/day) than males in a chronic rat bioassay. At higher doses, chronic nephropathy has also been observed as early as 90 days in a subchronic rat study. A comparison of the results of subchronic and chronic studies demonstrate that duration of dosing has an impact on toxicity. In the F-344 rat, the chronic NOAEL for chronic nephropathy is 14-fold lower than that derived in a subchronic bioassay using the same strain of rats.

An increase in toxicity of malathion with increased study duration was also indicated in the dog studies by the manifestation of liver, kidney, thyroid/parathyroid and hematological effects (other than cholinesterase inhibition) in the 1-year study at doses which caused only clinical signs, plasma and erythrocyte cholinesterase inhibition and minimal suppression of body weight gain in the 28-day study.

With long term oral exposure, mice and rats exhibited microscopic lesions of the nasal cavity and larynx at high doses of malathion (>327 mg/kg bw/day). Although the nasal lesions could be attributed to direct contact with malathion (by volatilization from the feed or by inhalation of the feed through the nose), the possibility that these lesions could be due to systemic toxicity could not be ruled out. Short term inhalation exposure in the rat produced similar lesions of the nasal cavity and larynx albeit at the much lower concentration of 0.1 mg/L (approximately 25.8 mg/kg bw/day). A NOAEC for these nasal effects following repeated exposure via inhalation was not established. The liver and nasal cavity epithelium were also identified as target organs of toxicity in studies with malaoxon.

In contrast to the rat and dog oral studies, rabbits exposed via the dermal route up to 1000 mg/kg bw/day for 21 days exhibited no systemic effects of toxicity other than cholinesterase inhibition. Due to the unique physiological and biochemical characteristics of rabbits, the results of dermal toxicity studies in rabbits have the potential to underestimate the toxicity of organophosphates. The blood of rabbits has a high level of arylesterases relative to both rats and humans. Arylesterases are key enzymes involved in the breakdown of S=organophosphates and serum arylesterases may break down these chemicals prior to activation by the liver following dermal exposure. However, in the case of malathion, carboxylesterase is likely the dominant enzyme in the detoxification of malathion and malaoxon.

Evidence of this includes:

1. The high levels of carboxylesterase degradate products in the urine (>80%);
2. The similarity of acute subcutaneous LD_{50s} in the rat and the rabbit despite rabbits having substantially higher serum arylesterase activity than rats (Brealey, 1979; ChemID, 2008; Costa et al., 1990); and
3. An increase in oral LD₅₀ of over 100-fold following the inhibition of carboxylesterase in rats (Murphy et al., 1959; Dauteran and Main, 1966)

Dermal toxicity studies in a species other than rabbit were not provided. A comparison of dermal absorption between rats and rabbits suggests that rabbits have a substantially greater capacity for the dermal absorption of malathion (Dary et al., 1994; Dary et al., 2001; Saleh et al., 1997; Shah and Guthrie, 1976; Wester and Noonan, 1980).

Assessment of the relative sensitivity of cholinesterase activity with oral dosing reveals no appreciable species differences between mice, rats and dogs. Similarly, studies conducted via all exposure routes do not suggest a sex difference in sensitivity to the effects of malathion on cholinesterase inhibition.

Results of the guideline genetic toxicology studies with malathion indicate that the test material did not cause gene mutations in bacteria or unscheduled DNA synthesis in cultured rat hepatocytes. Similarly, malathion was neither clastogenic nor aneugenic following *in vivo* exposure to rats. Some *in vitro* and *in vivo* genotoxicity studies with malathion obtained from published literature have shown positive evidence of clastogenicity. However, the relevance of these findings is not clear since the positive results were seen usually at cytotoxic doses. In addition, the identity and/or purity of the test substance was an issue in some studies. Available data does not indicate a genotoxic hazard with malathion.

In chronic/oncogenicity studies performed with malathion in mice and rats, treatment-related increases in benign tumor incidences were observed in the liver (mouse, rat) and in the nasal/oral cavity (rat). EPA's classification of malathion based on the weight of the evidence is "suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential". Other regulatory bodies (JMPR, UK MAFF) have determined that malathion has no oncogenic potential.

The PMRA has concluded that the liver tumours in both sexes of mice and in female rats occur at doses of malathion which exceed the maximum tolerated dose (MTD). From the weight of evidence, malathion is unlikely to possess carcinogenic potential for humans based on the following information:

1. The MTD was exceeded in mid and high dose male and female mice and in high dose rats, such as increased mortality, decreased body weight gain > 10%.
2. No evidence of progression from non-neoplastic (such as hyperplasia) to neoplastic lesions.
3. All tumours were benign ie. no progression from benign to malignant
4. No dose-response in tumour incidence at dose levels below those deemed to be excessively toxic.
5. No evidence of decrease in tumour latency.
6. The liver is the site of metabolism of malathion and demonstrated signs of metabolic saturation
7. Liver tumours are a common neoplasm in mice.
8. The organophosphates are not, generally speaking, known to be carcinogenic.
9. Malathion and malaoxon (the active metabolite) are not genotoxic.

The single incidences of nasal/oral tumours cannot be distinguished as treatment-related or due to random occurrence. In view of the rare nasal/oral cavity tumours observed in the rat in the dietary study and the moderate-to-severe lesions of the nasal cavity and larynx in a 2-week range-finding inhalation exposure study, the PMRA has concern that no carcinogenicity study via the inhalation route is available for evaluation. This lack of information is taken into consideration in the risk assessment, particularly for workers who may be occupationally exposed to malathion.

Malaoxon is not mutagenic in bacteria but is weakly clastogenic in cultured Chinese hamster ovary (CHO) cells. Malaoxon is positive in the mouse lymphoma assay without metabolic activation, although only at cytotoxic dose levels. Although malaoxon is structurally similar to malathion, studies showed it not to be carcinogenic in male or female Fischer 344 rats.

Malathion was evaluated for developmental toxicity in rats and rabbits. In rabbits, developmental effects (slightly increased incidence of dams with resorptions) were noted at 50 mg/kg bw/day and greater along with maternal toxicity. A slightly increased incidence of dams with resorption sites was also observed in a rat developmental toxicity study at the highest dose tested (800 mg/kg/day) and in the presence of maternal toxicity. Neither developmental study showed evidence of treatment-induced malformations. The developmental toxicity data does not indicate a sensitivity of the young following *in utero* exposure to malathion. Malathion did not induce reproductive toxicity in rats at the highest dose tested in a two-generation study.

The recent review of the developmental neurotoxicity (DNT) study and related comparative cholinesterase studies with malathion provides evidence of quantitative and qualitative sensitivity of juvenile rats. This susceptibility was observed in terms of the dose level at which effects (cholinesterase inhibition) were observed and the magnitude of the responses (for example, when inhibition was noted for both age groups at the same level, the percent inhibition was substantially greater for pups than for young adults). The developmental neurotoxicity study also demonstrated behavioural effects in juvenile rats at doses eliciting a reduction in erythrocyte cholinesterase activity.

To refine the risk assessment, benchmark dose analysis was conducted on cholinesterase data for several critical studies. This allows for both a more accurate point of departure to be used in risk assessment, and a direct comparison of the inhibitory effects of malathion on cholinesterase in both adults and children. Maintaining its current approach for the interpretation of erythrocyte cholinesterase inhibition data, the PMRA has selected a benchmark dose response of 20% for analysis, where applicable. Benchmark dose analysis of EChE inhibition in the comparative cholinesterase assay indicates that juvenile animals are 6.4 and 1.8 times more sensitive than adults following acute and repeat dose exposures, respectively. This knowledge of the differential susceptibility of juvenile animals is reflected in the human health risk assessment for malathion.

Chronic dosing studies in rats with the activated metabolite malaoxon demonstrated inhibition of erythrocyte and brain cholinesterase inhibition at much lower dose levels than those noted in similar studies conducted in rats exposed to malathion. The increased potency of malaoxon has also been observed in both acute and short-term repeat oral dose studies aimed at establishing the relative potency of malathion to malaoxon. A comparison of benchmark dose responses reveals that malaoxon is 24-fold more potent than malathion in the inhibition of EChE following acute or repeat oral exposure in rats. Accordingly, a toxicity adjustment factor of 24-fold is used to convert exposures of malaoxon into exposure equivalents of malathion.

There is insufficient evidence to indicate that malathion affects the endocrine system. There is some indication that malathion may elicit an immune response in experimental animals. Published studies indicate that malathion has the potential to affect both humoral and cellular immunity, including effects on IgM antibodies and the respiratory burst of macrophages, although no guideline of immunotoxicity study has been submitted to the PMRA to date. Confirmatory data will be required.

An available human study has been used in a supplementary manner to confirm that the animal model is an appropriate surrogate for assessing toxicity in humans (EChE depression was identified in the human volunteer study). This is corroborated by poison control centre findings which associate malathion exposure in humans with cholinergic symptoms.

3.1.1 PCPA Hazard Consideration

For assessing risks from potential residues in food, as well as uses around homes and schools, the PCPA requires the application of an additional 10-fold factor to threshold effects. This factor should take into account completeness of the data with respect to the exposure of, and toxicity to, infants and children's potential pre- and post-natal toxicity. A different factor may be determined to be appropriate on the basis of reliable scientific data.

With respect to the toxicity database, the database is complete. The current database addressing risk to the young following malathion exposure includes a multigenerational reproductive toxicity study, a developmental toxicity study in rats and a developmental toxicity study in rabbits. As a known neurotoxicant, additional studies have been developed to investigate the neurotoxic potential of malathion with regards to the young including a developmental neurotoxicity study combined with a companion comparative cholinesterase study and two studies (acute and short-term exposures) investigating the effects of malathion and malaoxon on preweanling rats.

Data from the two acceptable developmental toxicity studies, a reproductive toxicity study and a developmental neurotoxicity study do not suggest a concern for the sensitivity of the young following *in utero* exposure. However the current neurotoxicity database, including the developmental neurotoxicity assay, the comparative cholinesterase study and the two assays investigating the comparative toxicity of malathion and malaoxon suggest that preweanling pups are more sensitive to the effects of malathion on erythrocyte cholinesterase, a critical endpoint of concern for malathion. Benchmark dose calculations from the comparative cholinesterase assays suggest that the young are approximately 6.4x and 1.8x more sensitive to the cholinesterase inhibiting effects of malathion compared to adults following acute and repeat dose oral exposure, respectively. A comparison of additional studies measuring cholinesterase in preweanling pups and adults reinforces this finding.

In the rabbit developmental toxicity assay, an increase in resorptions (embryo-fetal death) was observed at the LOAEL and in the presence of maternal toxicity. An increase in resorptions (in the presence of maternal toxicity) is considered a serious endpoint and is considered in the designation of the PCPA factor where applicable to ensure adequate margins of exposure to the unborn child.

Overall, the database is adequate for determining the sensitivity of the young. The sensitivity of the young is well characterized and the data suggests that the young are more susceptible to the neurotoxic effects of malathion following exposure from the oral route.

3.2 Occupational and Non-Occupational Risk Assessment

Occupational and non-occupational risk is estimated by comparing potential exposures with the most relevant endpoint from toxicology studies to calculate a margin of exposure (MOE). This is compared to a target MOE incorporating uncertainty factors protective of the most sensitive subpopulation. If the calculated MOE is less than the target MOE, it does not necessarily mean that exposure will result in adverse effects. However, MOEs less than the target MOE require measures to mitigate (reduce) risk.

3.2.1 Toxicology Endpoint Selection for Occupational and Bystander Risk Assessment

3.2.1.1 Short-, intermediate-, and long-term dermal endpoint(s)

For the **short- and intermediate-term dermal risk assessment for adults (occupational and non-occupational)**, an oral NOAEL of 25 mg/kg bw/day from the developmental toxicity study in rabbits was selected. In this study, an increase in resorptions was observed at the LOAEL of 50 mg/kg bw/day. A developmental toxicity study in which malathion was administered dermally was not available.

Standard uncertainty factors (10-fold for interspecies extrapolation and 10-fold for intra-species variability) are applied. Some concern for the increase in resorptions is alleviated by the endpoint being observed in the presence of maternal toxicity. However, concerns remain for the health of the unborn child and an additional 3-fold factor was applied to account for the seriousness of the endpoint. The **Margin of Exposure (MOE)** selected when using this study and endpoint is **300**.

This target MOE provides a margin of 1338 to the BMDL₂₀ established for erythrocyte cholinesterase inhibition following dermal exposure in rabbits.

For the **short- and intermediate- term dermal risk assessment for children**, a 21-day dermal study in rabbits was selected in which a BMDL₂₀ of 107 mg/kg bw/day for EChE inhibition was calculated. In this study, EChE inhibition in adult rabbits provided the most sensitive point of departure.

As discussed previously, there have been concerns with using a dermal toxicity study in rabbits for the determination of organophosphate toxicity. However, in the case of malathion, there is a low level of concern for the rabbit toxicity study being underprotective for the toxicity of malathion. The use of this study is considered protective of human health due to the low contribution of serum arylesterases in the detoxification of malathion/malaoxon and the increased dermal absorption in rabbits relative to rats and humans.

However, the dermal study was conducted in adult rabbits and not in the young, which have been demonstrated to be 1.8x more sensitive to EChE inhibition following repeat-dose oral exposure to malathion. The available oral database indicates that this increased sensitivity is limited to postnatal animals and that there is no increased susceptibility of the unborn animal to cholinesterase inhibition. Uncertainty remains as to whether the children would be more susceptible to the cholinesterase inhibiting effects of malathion following dermal exposure.

In addition to the standard uncertainty factors (10-fold for interspecies extrapolation and 10-fold for intraspecies variability), an additional 3-fold uncertainty factor is being applied for database deficiencies (such as the lack of data on the sensitivity of the young following dermal exposure). The PCPA factor has been reduced to 1-fold as residual uncertainties have been subsumed in the uncertainty factor for database deficiency. The **Margin of Exposure (MOE)** selected when using this study is **300**.

For the **long-term dermal risk assessment for adults (occupational)**, an oral NOAEL was selected due to the lack of availability of a dermal study of sufficient duration. The oral NOAEL of 3.0 mg/kg bw/day from the rat chronic carcinogenicity study was selected for risk assessment, based on an increased severity of chronic progressive nephropathy in female rats at 32 mg/kg bw/day. The target **Margin of Exposure (MOE)** selected when using this study is **100**, accounting for the standard uncertainty factors (10-fold for interspecies extrapolation and 10-fold for intraspecies variability). This would provide a margin of 833 to the developmental NOAEL of 25 mg/kg bw/day. This target MOE would, therefore, be considered protective of female workers of child-bearing age and their unborn children.

A long-term dermal risk assessment is not required for children.

3.2.1.2 Short-, intermediate-, and long-term inhalation endpoint(s)

For **short-, intermediate- and long term inhalation risk assessment for the general population (including children)**, the LOAEC of 0.1 mg/L (equivalent to 25.8 mg/kg bw/day) was selected from a 90-day inhalation toxicity study in rats. The LOAEC was established based on the observation of lesions in the respiratory epithelium. The target **Margin of Exposure (MOE)** selected when using this study and endpoint is **1000**. Standard uncertainty factors of 10-fold for interspecies extrapolation and 10-fold for intraspecies variability were employed, with an additional uncertainty factor of 10-fold due to a lack of an identified NOAEL with consideration of the nature of the effect and for the potential development of nasal cavity tumours. For non-occupational assessment, the database for addressing toxicity to children is considered complete (see PCPA hazard consideration section) and the endpoint chosen is considered protective of concerns related to the sensitivity of the young. The PCPA factor is therefore reduced from 10-fold to 1-fold. This MOE would provide margins of 969 to the developmental NOAEL of 25 mg/kg bw/day, and 116 to the chronic oral NOAEL of 3.0 mg/kg bw/day. This target MOE would therefore be considered protective of females (including workers of child-bearing age) and their unborn children.

A long-term inhalation risk assessment for children is not required.

3.2.1.3 Non-dietary (incidental) Oral Ingestion by Children

For **non-dietary oral ingestion by children**, the oral NOAEL of 5 mg/kg bw/day from the developmental neurotoxicity study in rats was selected based on decreased motor activity in female rats tested on PND22/23 following exposure to 50 mg/kg bw/day.

Standard uncertainty factors are applied (including 10-fold for interspecies extrapolation and 10-fold for intraspecies variability). While sensitivity of the young has been demonstrated, the most sensitive endpoint following short-term exposure (neurobehavioural effects) to young animals is being used as a point of departure. In light of the complete database (see PCPA hazard consideration section) and the endpoint chosen, the PCPA factor has been reduced from 10-fold to 1-fold. The target **Margin of Exposure (MOE)** selected when using this study is **100**.

3.2.1.5 Dermal Absorption

Based on the weight-of-evidence from published studies, it was concluded that the majority of the presented data support the use of a 10% dermal absorption factor.

3.2.2 Occupational Exposure and Risk Assessment

Workers can be exposed to malathion through mixing, loading or applying the pesticide, and when entering a treated site to conduct activities such as scouting and /or handling of treated crops.

3.2.2.1 Mixer, Loader and Applicator Exposure and Risk Assessment

There are potential exposures to mixers, loaders, and applicators. The following supported uses were assessed:

- Mixing/loading of liquid, wettable powder, and dust formulations
- ULV aerial application to barley, canola, oats, wheat, rye, wild rice (cultivated), alfalfa, clover, sweet clover, canary grass (for seed), rapeseed, rape, mustard, flax, and residential areas
- ULV groundboom application to alfalfa, clover, canary grass, corn (grain, forage), sweet clover, cereal crops, pastures and ranges, grasses or legumes being grown for hay, barley, canola, oats, wheat, rye, wild rice (cultivated), nongrass animal feed, rapeseed, rape, mustard, flax, and residential areas
- Handwand or backpack sprayer application to flour mills, grain elevators, granary bins (empty), grain box cars, mushroom beds/houses, greenhouse lettuce, greenhouse ornamentals, dairy and beef cattle, goats, sheep, swine, poultry, stored wheat, oats, corn, rice, rye and barley, raspberries, currants, gooseberries, blueberries, blackberries, boysenberries, dewberries, loganberries, strawberries, flour mills, flour mill warehouses, feed mills, dwelling foundations, in and around buildings that house domestic animals,

around yards, homes, processing plants, and other buildings: walls, ceilings, stanchions, windows, fences, garbage cans, and manure piles, outdoor ornamentals, garden areas, and outside foundations

- Aerial application to alfalfa, clover, canary grass, corn (grain, forage), cereal crops, pasture and range, grasses or legumes being grown for hay, sweet clover, barley, canola, oats, wheat, rye, wild rice (cultivated), rapeseed, rape, mustard, and flax.
- Groundboom application to alfalfa, clover, canary grass, corn (grain, forage), sweet clover, cereal crops, pasture and range, grasses or legumes being grown for hay, potato, beets, turnips, carrots, horseradish, parsnip, leaves of root and tuber vegetables, bulb vegetables, leafy vegetables, legume vegetables, fruiting vegetables, cucurbit vegetables, berries, cereal grains, canary grass (for seed), rapeseed, rape, mustard, flax, asparagus, strawberries, tobacco, and cranberries
- Airblast application to apricots, apples, pears, peaches, plums, prune plums, cherries, raspberries, currants, gooseberries, blueberries, blackberries, boysenberries, dewberries, loganberries, grapes, and ornamentals
- Chemigation to cranberries
- Mixing/loading of a dust for treatment of wheat, oats, corn, rice, rye and barley grains during storage
- Dust application to dairy and beef cattle, and swine
- Backrubber application to dairy and beef cattle

Due to the number of agricultural applications per year (ranging from 1 to 5), exposure is likely to be short- to intermediate- term (such as up to several months) in duration. Exceptions would be the following where exposure is expected to be long-term (> 6 months):

- Mushroom Beds/Houses
- Greenhouse Lettuce
- Greenhouse Ornamentals

The PMRA estimated handler exposure based on different levels of personal protective equipment:

- Long pants, long sleeved shirts, and chemical-resistant gloves
- Cotton coveralls over long pants, long sleeved shirts, and chemical-resistant gloves.
- Chemical-resistant coveralls, over long sleeves and long pants, and chemical-resistant gloves

In most cases, PHED did not contain appropriate data sets to estimate exposure to workers wearing coveralls or chemical-resistant coveralls. This was estimated by incorporating a 75% clothing protection factor for coveralls, and a 90% clothing protection factor for chemical-resistant coveralls into the unit exposure data. Inhalation exposures were based on light inhalation rates (17 LPM) except for backpack applicator scenarios which were based on moderate inhalation rates (27 LPM).

Mixer/loader/applicator exposure estimates are based on the best available data at this time. Dermal and inhalation exposures were estimated using data from the Pesticide Handlers Exposure Database (PHED). The PHED is a compilation of generic mixer/loader applicator passive dosimetry data with associated software that facilitates the generation of scenario-specific exposure estimates based on formulation type, application equipment, mix/load systems and level of PPE.

3.2.2.1.1 Occupational Exposure Risk Estimates

Occupational risk estimates associated with mixing, loading, and applying product for agricultural and livestock uses generally meet the targets provided engineering controls and/or PPE are used as summarized in Section 8. Table 1 of Appendix IV summarizes the calculated risks for mixer/loaders and applicators.

3.2.2.2 Postapplication Worker Exposure and Risk Assessment

The postapplication occupational risk assessment considered exposures to workers who re-enter treated sites to conduct agronomic activities involving foliar contact (for example, pruning, thinning, harvesting, or scouting). Based on the malathion use pattern, there is potential for short- to intermediate-term (>1 day- 6 months) post-application exposure for the majority of scenarios and long-term exposure (>6 months) for greenhouse workers.

Potential exposure for post-application workers was estimated using activity-specific transfer coefficients (TCs) and dislodgeable foliar residue (DFR) values. The TC is a measure of the relationship between exposure and DFRs for individuals engaged in a specific activity, and is calculated from data generated in field exposure studies. The technical registrant, Cheminova, is a member of the Agricultural Re-entry Task Force (ARTF) that provides these data.

Dislodgeable foliar residue data from 7 ARTF studies were assessed to determine the dissipation rate of malathion. These studies were conducted on various agricultural crops at various locations and represent a variety of typical scenarios. Based on the data, the mean daily dissipation rate of 36% was used in the re-evaluation post-application exposure assessment for malathion. The default peak DFR level of 20% of the application rate being dislodgeable on day 0 was used to assess exposure immediately following application.

For greenhouse ornamental uses, a chemical-specific ARTF DFR study that was conducted in greenhouses was used. To estimate exposure on the day of application (day 0), the standard default of 20% of the application rate being dislodgeable was used. To assess exposure following application, average DFR values on each day (days 1 to 3) following application were used. This study was generally well conducted and is considered acceptable for risk assessment purposes.

For mushroom houses and structural sites (such as flour mills), data was not available to assess potential post-application exposure. This is considered a data gap, and additional data will be required, as outlined in Section 8.

For livestock uses, data was not available to assess potential post-application exposure. However, postapplication exposure is expected to be minimal. Additional use pattern data will be required as outlined in Section 8.

For workers entering a treated site, restricted entry intervals (REIs) are calculated to determine the minimum length of time required before individuals can safely enter after application. An REI is the duration of time that must elapse before residues decline to a level where performance of a specific activity is expected to result in exposures above the target MOE (such as, >300 for short-to-intermediate term dermal and >100 for long-term dermal).

To achieve the target MOEs for post-application workers in agricultural scenarios, new REIs need to be implemented. Appendix XXII summarizes the calculated REIs, which are proposed to be added to the label. Since the post-application exposure assessment is based on the maximum number of applications and minimum interval between applications, these also need to be specified on the label.

The proposed REIs are considered to be agronomically feasible.

3.2.3 Non-Occupational Exposure and Risk Assessment

Residential risk assessment estimates risk to the general population, including children/youths, during or after pesticide application.

3.2.3.1 Residential Mixer, Loader, and Applicator Exposure and Risk Assessment

Exposure estimates for residential applicators are based on PHED and Outdoor Residential Exposure Task Force (ORETF) data. For the residential scenario, exposure estimates are based on homeowners wearing short pants, short sleeves, and no gloves.

Based on the expected number of applications (two per year), homeowners applying malathion would generally have a short-to-intermediate term (>1 day to several months) duration of exposure.

The calculated MOE for short-to-intermediate term exposure risk exceeds the target MOE for mixing, loading, and application based on the current label use (ornamentals, fruit and vegetable gardens, and foundations) and, therefore, is not of concern. See Appendix V, Table 1 for more information.

3.2.3.2 Residential Post-Application Exposure and Risk Assessment

For adults and children, there is potential for acute to short-term exposure (such as from one to 30 days) to malathion through contact with transferable residues following application of malathion to vegetables and fruits, outdoor ornamentals, and following usage of malathion in mosquito abatement programs. Post-application exposure following application to foundations, exterior wall surfaces, and under fences and shrubs, is expected to be minimal.

3.2.3.2.1 Residential Gardens (Vegetables and Fruits) and Ornamentals

Postapplication exposure to residential gardens includes dermal exposure to adults and youths. Toddlers are not expected to perform gardening activities (such as hand harvesting, weeding). Post-application exposure to residential gardens and ornamentals is therefore considered to be minimal.

An acute and short-term scenario was conducted for the post-application exposure assessment. The acute scenario assumes that the homeowner or youth would be exposed to peak residues immediately following application. The short-term scenario used a time-weighted average of DFR values over 30 days. The standard default of 20% of the application rate being dislodgeable on day 0 was refined to 16% based on ARTF chemical-specific data for the acute assessment, and 2% of the application rate for the short-term assessment. The DFR value of 2% of the application rate takes into account 36% dissipation per day from ARTF chemical-specific data.

Calculated MOEs exceed the target MOE except for one end-use product with a higher application rate for garden areas and the acute assessment for adults. The acute scenario for adults is not of concern since the calculated MOE (295) approached the target MOE of 300 and given the conservative nature of the assessment (Appendix V, Table 2). Mitigation measures for the product with the higher application rate is described in Appendix XXII.

3.2.3.2.2 Bystander Exposure

There is potential for exposure to adults and children during or immediately following application of malathion in mosquito abatement programs (for example, people re-entering treated lawns).

Post-application exposure estimates were generated following the US EPA Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments and the recommended revisions by the US EPA Science Advisory Council (US EPA, 1997; 2001). The assumptions outlined in the SOP generally result in high-end estimates of exposure. Exposure estimates were generated for a 70 kg adult, 39 kg youth, and a 15 kg child (representative of a toddler). The assumptions and inputs used to estimate bystander exposure are tabulated in Appendix VI, Table 1.

Estimates of dermal and inhalation exposure were generated for adults, youth, and children, while on turf during or immediately after application. Exposure estimates were generated using the same assumptions as outlined in 2003 regulatory document for malathion (PACR 2003-10): *Re-evaluation of Malathion*.

There is a lack of data available to characterize malaoxon formation on turf. Even though monitoring data that is currently available suggests that malaoxon formation would be minimal, this is considered a data gap, and additional data will be required, as outlined in Section 8.

Bystander risk estimates are above the target MOE for all exposure routes and scenarios associated with either ground ULV or aerial ULV applications, and are therefore not of concern. The MOEs that were attained were sufficiently large and thus are anticipated to provide further accommodation for those with environmental sensitivities. The MOEs would be further enhanced through measures such as remaining indoors during or immediately after spraying.

Exposure from Malathion and Malaoxon Residues on Outdoor Hard Surfaces

Malaoxon is a degradation product of malathion, which forms on hard, anthropogenic surfaces such as decks and playstructures. Dermal exposure estimates were generated for adults and youths, and dermal and non-dietary oral exposure estimates were generated for children from recreational activities on outdoor hard surfaces.

Consistent with the US EPA RED for malathion (2006), it was assumed that malathion transforms to malaoxon at a peak of 10%. This was the maximum amount of malathion that was transformed to malaoxon in monitoring studies on any media (turf, sand, soil, stainless steel plates, and plants), and thus is considered to be an upper end estimate. Standard defaults for indoor hard surfaces from the US EPA Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments and the recommended revisions by the US EPA Science Advisory Council (US EPA, 1997; 2001) were used in the assessment. Indoor hard surfaces was considered to be representative of exposure from outdoor hard surfaces. The assumptions and inputs used to estimate exposure are outlined Appendix VI, Table 2.

Risk estimates are above the target MOE for all scenarios, and are therefore not of concern.

3.3 Dietary Exposure and Risk Assessment

In a dietary exposure assessment, the PMRA determines how much of a pesticide residue, including residues in fruits, vegetables, milk, meat, eggs and processed products, may be ingested with the daily diet. These dietary assessments are age-specific and incorporate the different eating habits of the population at various stages of life (infants, children, adolescents, adults and seniors). For example, assessments take into account differences in children's eating patterns, such as food preferences and the greater consumption of food relative to their body weight when compared to adults. Dietary risk is then determined by the combination of the exposure and the toxicity assessments. High toxicity may not indicate high risk if the exposure is low. Similarly, there may be risk from a pesticide with low toxicity if the exposure is high. The PMRA considers limiting use of a pesticide when risk exceeds 100% of the reference dose. The PMRA's Science Policy Note SPN2003-03, *Assessing Exposure from Pesticides, A User's Guide*, presents detailed acute and chronic risk assessment procedures.

Residue estimates used in the dietary risk assessment (DRA) may be conservatively based on the maximum residue limits (MRL) or the field trial data representing the residues that may remain on food after treatment at the maximum label rate. Surveillance data representative of the national food supply may also be used to derive a more accurate estimate of residues that may remain on food when it is purchased. These include the Canadian Food Inspection Agency's National Chemical Residue Monitoring Program (2002-2007) and the United States Department of Agriculture Pesticide Data Program (PDP, 2004-2005).

Acute, chronic, non-cancer and cancer dietary risk assessments were conducted using the Dietary Exposure Evaluation Model – Food Commodity Intake Database (DEEM-FCID™, Version 2.03), which uses food consumption data from the USDA's Continuing Surveys of Food Intakes by Individuals (CSFII) from 1994 to 1996 and 1998. The analyses were performed to support the re-evaluation eligibility for continuing registration for malathion and its metabolite malaoxon.

This PRVD is based on an updated assessment of malathion following recent revisions in toxicology, monitoring data, registered commodities and drinking water estimates that became available after the previous regulatory document for malathion (PACR 2003-10). The most important change in risk estimates arose from setting a Toxicity Adjustment Factors (TAF) for malaoxon at 24 times the parent toxicity, which resulted in reconsideration of values assigned to undetected residues from monitoring surveys, and a re-evaluation of drinking water exposure. In particular, the TAF of 24 implied that risk contribution of malaoxon residues below LOD could be more important than detected residues of its parent, malathion. This uncertainty, coupled with important data gaps on magnitude of residues, field trials studies, and measurement of malaoxon, called for conservative assumptions. To that end, both malathion and malaoxon residues and their limits of detection were combined by converting the malaoxon residues into malathion equivalents, where one equivalent is 24 times the malaoxon residues.

The PMRA estimated the dietary exposure arising from pick-your-own (PYO) operations with an additional exposure equal to the 95th percentile intake of the fresh produce found in the CSFII database. This assumption did not consider the duration of PYO activities, or if the intensity of on-site consumption can be adequately deduced from the intake of market produce. It also did

not consider additional non-dietary exposures during PYO, including dermal exposure. No relevant studies are available. Exposure estimates were aggregated with the occupational assessment in section 3.5.3.

The combined dietary exposure and risk estimates for malathion and its malaoxon metabolite are summarized in Appendix VIII (Table 1 and 2 respectively).

3.3.1 Determination of Acute Reference Dose

Acute Reference Dose (ARD) for the general population (including children)

To estimate acute dietary risk (1-day) of malathion to the **general population**, the BMDL₂₀ of 23.4 mg/kg bw/day, from a cholinesterase study comparing the acute toxicity of malathion and malaoxon to rats, was used as a point of departure in the risk assessment. In this study, PND11 male rats dosed acutely represented the most sensitive population for erythrocyte cholinesterase inhibition, for which the benchmark dose was calculated.

While sensitivity of the young has been demonstrated, the most sensitive endpoint (EChE inhibition) following acute exposure (cholinesterase inhibition) to young animals (preweanling rats) is being used as a point of departure. Standard uncertainty factors were applied (10-fold for inter-species extrapolation and 10-fold for intra-species variability). In light of the complete database (see PCPA hazard consideration section) and the endpoint chosen, the PCPA factor has been reduced from 10-fold to 1-fold. The composite assessment factor (combined uncertainty factors and PCPA factor) is 100.

$$ARD = \frac{23.4 \text{ mg/kg bw}}{100} = 0.23 \text{ mg/kg bw (general population)}$$

Acute Reference Dose (ARD) for females aged 13-49

To estimate acute dietary risk (1-day) for the **females aged 13-49**, the NOAEL of 25 mg/kg bw/day from the developmental toxicity study in rabbits was selected. In this study, an increase in resorptions was observed at the LOAEL of 50 mg/kg bw/day. Some concern for the increase in resorptions is alleviated by the endpoint being observed in the presence of maternal toxicity. In consideration of the nature of the endpoint, its use as the point of departure and the completeness of the database (see PCPA hazard consideration section), the PCPA factor has been reduced from 10-fold to 3-fold. Standard uncertainty factors were applied (10-fold for interspecies extrapolation and 10-fold for intra-species variability). The composite assessment factor is 300.

$$ARD = \frac{25 \text{ mg/kg bw}}{300} = 0.08 \text{ mg/kg bw (females aged 13-49)}$$

3.3.2 Acute Dietary Exposure and Risk Assessment

Acute dietary risk is calculated considering the highest ingestion of malathion that would be likely on any one day, and using food consumption and food residue values. A statistical analysis allows all possible combinations of consumption and residue levels to be combined to estimate a distribution of the amount of malathion residue that may be consumed in a day. A value representing the high end (99.9th percentile) of this distribution is compared to the ARD, which is the dose at which an individual could be exposed on any given day and expect no adverse health effects. When the expected intake of residues is less than the ARD, then acute dietary exposure is considered to be acceptable.

Acute dietary exposure includes food and drinking water. It was the highest for children and infants (101%) and women (89%). Since assumptions for both drinking water and concentrations of malaoxon in food were conservative, the PMRA did not consider acute dietary risk to be of concern (Appendix VIII, Table 1), even if exposure to infants was marginally above threshold. The estimated 100% conversion of malathion to malaoxon during chlorination at the treatment plant caused drinking water to be the main risk driver (Appendix VIII, Table 1, water only).

3.3.3 Determination of Acceptable Daily Intake

Acceptable Daily Intake (ADI) for general population (including children)

To estimate dietary risk from repeat exposure, the NOAEL of 3.0 mg/kg bw/day from the chronic toxicity/ carcinogenicity assay in rats was used for risk assessment. In this study, an increase in severity of chronic progressive nephropathy was observed at 32 mg/kg in female rats. While sensitivity of the young has been demonstrated, the most sensitive endpoint following repeat exposure (behavioural effects) to young animals occurs at doses exceeding the NOAEL for chronic nephropathy. Chronic nephropathy is a disease related to ageing and has been observed following long-term exposure in adult rats. Standard uncertainty factors were applied (10-fold for inter-species extrapolation and 10-fold for intra-species variability). In light of the complete database (see PCPA hazard consideration section) and the endpoint selected, the PCPA factor has been reduced from 10-fold to 1-fold. The composite assessment factor is 100.

$$\text{ADI} = \frac{3 \text{ mg/kg bw/day}}{100} = 0.03 \text{ mg/kg bw/day}$$

In consideration of the effects on motor activity observed in the developmental neurotoxicity study, there is a margin of 167 between this ADI and the offspring NOAEL of 5 mg/kg bw/day. In consideration of the increased incidence of does with resorptions observed in the rabbit developmental study, there is a margin of 833 between this ADI and the developmental NOAEL of 25 mg/kg bw/day. The ADI is therefore considered protective of infants and children.

3.3.4 Chronic Dietary Exposure and Risk Assessment

Chronic exposure for both food and water were below the level of concern. Children of 1 to 2 years were the most exposed at 66 % of the ADI. Results appear in Table 2 (Appendix VIII).

3.4 Exposure from Drinking Water

There is sufficient evidence showing complete conversion of malathion to malaoxon in chlorinated waters. Full conversion is also supported by a survey of 1999-2000 where malaoxon was detected in finished waters, but not in the reservoir feeding the processing plant. Drinking water exposure was therefore derived from the highest malathion drinking water estimates obtained from model and monitoring data, and then multiplied by TAF=24 to represent malaoxon. These values were directly inserted into DEEM calculations (Appendix VIII, Table 3). Direct insertion is preferable to the Drinking Water Level of Comparison (DWLOC) method since inputting water concentrations like any other food commodity returns a more accurate estimate of the drinking habits of sub-populations.

3.4.1 Concentrations in Drinking Water

The acute concentrations of malathion in surface water are reported as a range consisting as an upper bound and lower bound concentration rather than a discrete exposure value (Appendix VIII, Table 3). The upper bound value is represented as the concentration estimated by PRZM-EXAMS for the one-in-ten year exposure (or 90th percentile). The lower end of the range was derived from the available monitoring data and represents the highest value acceptable for the environment. The lower bound acute exposure value was estimated from monitoring data by determining the 95th percentile of the maximum concentration detected in the monitoring studies. The lower bound chronic exposure values were estimated by determining the 95th percentile of the arithmetic means of all samples at each site (detects and non-detects) from the monitoring studies whose samples were from potential drinking water sources. The samples with values less than the LOD were given a value of ½ LOD.

3.4.2 Drinking Water Exposure and Risk Assessment

Drinking water was the main driver of acute exposure and contributed 94% of the overall exposure from food and water. As such, the contribution of water was most important but below levels of concern. It resulted from assuming complete conversion of malathion to malaoxon to cover major uncertainties remaining in determining the risk of malaoxon in drinking water.

3.5 Aggregate Exposure and Risk Assessment

Aggregate exposure is the total exposure to a single pesticide that may occur from food, drinking water, residential, and other non-occupational sources, and from all known or plausible exposure routes (oral, dermal and inhalation).

Malathion is registered for use on residential vegetable and ornamental gardens, around dwelling foundations, and in mosquito abatement programs. As it is considered unlikely that acute dietary exposure would occur on the same day as exposure from residential uses, the acute aggregate assessment aggregates exposure from dietary and drinking water only. The short-term aggregate assessment combines dermal, and chronic dietary and drinking water exposures. It was assumed that adults would apply malathion to home vegetable and ornamental gardens on the same day that they would perform post-application activities such as weeding and pruning. However, it

was considered highly unlikely that a homeowner would apply malathion to their home garden on the same day that malathion would be applied in mosquito abatement programs. Thus, exposures resulting from the mosquitocide use were only aggregated with potential malathion exposure from food and drinking water.

Peak residues of malathion on turf are expected to occur immediately following application of malathion in mosquito abatement programs, and quickly dissipate thereafter. Results from environmental monitoring data (Neal *et al.*, 1993) found that the highest transformation of malathion to malaoxon (approximately 10%) occurred 21 days after application, at which time malathion residues on turf and in air are anticipated to be minimal. Therefore, it was considered highly improbable that an individual would be exposed to peak residues of malathion on turf and in air immediately following ULV application of malathion and peak residues of malaoxon on their deck and playstructures on the same day. Exposure to 10% malaoxon from decks and playstructures was aggregated with food and drinking water only.

3.5.1 Toxicology Endpoint Selection for Aggregate Assessment

Acute aggregate exposure

Acute aggregate exposure to malathion is comprised of dietary and drinking water exposures. In addition, an acute aggregate assessment was conducted for patrons of "Pick Your Own" farms, which included dermal exposure. The acute reference dose established for females ages 13-49 and for the general population (including children) are relevant for determining acute aggregate risk.

Short-term Aggregate Exposure

i) Children

Children's short-term aggregate exposure to malathion is comprised of contributions from food, residential exposure (dermal, inhalation and incidental oral components) and drinking water. Ideally, toxicity data reflecting the hazard associated with repeated exposure from the oral, dermal and inhalation routes would be relevant for risk assessment. In the absence of this data, extrapolation from other toxicity data is required. The oral NOAEL of 5 mg/kg bw/day from the developmental neurotoxicity study in rats was selected based on decreased motor activity in female rats tested on PND22/23 following exposure to 50 mg/kg bw/day. The oral endpoint has also been selected for aggregate assessment from the inhalation and dermal routes since this endpoint has not been investigated in route-specific assays.

While sensitivity of the young has been demonstrated, the most sensitive endpoint following short-term exposure (neurobehavioural effects) to young animals is being used as a point of departure. In light of the complete database (see PCPA hazard consideration section) and the endpoint chosen, the PCPA factor has been reduced from 10-fold to 1-fold. The target **Margin of Exposure (MOE)** selected when using this study is **100**; this accounts for the standard uncertainty factors of 10-fold for interspecies extrapolation and 10-fold for intraspecies variability.

In order to ensure that the aggregate risk assessment is protective of all endpoints, a separate assessment for the inhibition of EChE in children has been conducted. The analysis concluded that the use of decreased motor activity in preweanling rats was the most conservative point of departure for children's short-term aggregate risk assessment.

ii) Females aged 13-49

Short-term aggregate exposure of adults to malathion is comprised of contributions from food, residential exposure (dermal, inhalation and incidental oral components) and drinking water. Consequently, toxicity data reflecting the hazard associated with a short-term oral exposure would be relevant for risk assessment. For short-term exposure scenarios, the rabbit oral developmental toxicity study was selected. In this study, an increase in resorptions was observed at 50 mg/kg bw/day, with a NOAEL of 25 mg/kg bw/day.

The oral endpoint has also been selected for exposure from the inhalation and dermal routes since this endpoint has not been investigated in any route-specific assays. Standard uncertainty factors (10-fold for interspecies extrapolation and 10-fold for intra-species variability) are applied. In order to address concerns for the health of the unborn child, an additional 3-fold PCPA factor was applied to account for the seriousness of the endpoint. The target **MOE** when using this study is **300**.

iii) General Population (excluding children and females aged 13-49)

Short-term aggregate exposure of adults to malathion is comprised of contributions from food, residential exposure (dermal, inhalation and incidental oral components) and drinking water. Consequently, toxicity data reflecting the hazard associated with a short-term oral exposure would be relevant for risk assessment.

For short-term aggregate assessment for the general population, erythrocyte cholinesterase inhibition was selected as the critical endpoint. For exposure from the oral route, a BMDL₂₀ of 23.4 mg/kg bw/day was estimated for malathion from the repeat dose cholinesterase comparing malathion and malaoxon toxicity in which rats were exposed PNDs 11-21. A **MOE** of **100** is applied, consisting of the standard uncertainty factors of 10-fold for interspecies extrapolation and 10-fold for intraspecies variability.

For dermal exposure, a BMDL₂₀ of 107 mg/kg bw/day estimated from the 21-day dermal assay in rabbits was selected for EChE inhibition. A **MOE** of **100** is applied, consisting of the standard uncertainty factors of 10-fold for interspecies extrapolation and 10-fold for intraspecies variability.

For the inhalation route, a NOAEC of 0.1 mg/L (equivalent to 25.8 mg/kg bw/day) was selected for cholinesterase inhibition observed at the next highest dose in the 90-day inhalation study in rats. A **MOE** of **100** is applied to account for standard uncertainty factors of 10-fold for interspecies extrapolation and 10-fold for intraspecies variability.

No PCPA factor was applied for the general population aggregate assessment as separate assessments were conducted for children and females aged 13-49.

3.5.2 Aggregate Acute Exposure and Risk Assessment

"Pick Your Own (PYO)" farms are those that allow the public to harvest their own fruits and vegetables. As PYO fruit and vegetable operations become more and more prevalent, the PMRA recognizes the need for a means of assessing exposure to pesticides during hand-harvesting by members of the public. For the purpose of this risk assessment, "Pick Your Own" facilities are considered commercial farming operations that allow public access for harvesting in large-scale fields or orchards treated with commercially labelled malathion products.

Although there are many PYO operations involving a wide variety of produce across Canada, only a few orchard and berry crops can be readily eaten in an appreciable quantity during the harvest. For those PYO crops that do not represent acute, commodity-specific dietary exposure, the hand harvest exposure is covered off by the occupational post-application exposure assessment.

The PYO assessment for malathion focuses on apples and strawberries, which are likely candidates for consumption during harvest. In addition, the exposure incurred from harvesting or consuming apples and strawberries is considered to be representative of all orchard and berry crops that malathion is applied based on the current use pattern and dietary assessment (such as relatively high application rates, transfer coefficients, chronic and acute dietary exposure).

As there is potential for a person to be exposed through contact with treated foliage as well as eating the fruits that they are harvesting, both dermal and dietary exposure were aggregated in the PYO risk assessment.

Since members of the public who harvest at PYO facilities may be of any age, the risk assessment was conducted for toddlers, youths and adults. Two exposure pathways were considered: ingestion of fruit and dermal exposure through contact of the fruit while harvesting. Maximum residue limits (MRLs) were used to estimate the residue of fruits consumed. The MRL is the maximum residue found in field trials, as could potentially occur in a PYO scenario. Dislodgeable foliar residue data were used to estimate the residue dislodged for dermal exposure during harvesting. Acute consumption of apples and strawberries was based on the USDA Continuing Surveys of Food Intakes by Individuals, 1994-1996, 1998.

Potential exposure to malaoxon was not included in the dermal exposure assessment as monitoring data did not detect any malaoxon formation on the surface of plant material (tomato, lettuce). Acute dietary estimates for strawberries were based on the MRL, which was several times greater than the maximum amounts of malathion and malaoxon residues detected in monitoring studies. There was no detection of malaoxon residues in monitoring studies for apples.

The PYO risk assessment for malathion aggregated the dermal exposure from hand harvesting fruit, oral exposure from consumption of fresh fruit during harvest and chronic dietary exposure (to account for background exposure to malathion from all routes, including food and drinking water). Results of the aggregate PYO risk assessment are presented in Table 1 of Appendix VII.

Calculated MOEs exceed the target MOE for all sub-populations, and are not of concern.

3.5.3 Aggregate Short-Term Exposure and Risk Assessment

Calculated aggregate exposure estimates exceed the target MOE for all sub-populations (Appendix VII, Table 2), and are therefore, not of concern.

3.6 Incident Reports

Starting April 26, 2007, registrants are required by law to report incidents, including adverse effects to health and the environment, to the PMRA within a set time frame. Incidents are classified into six major categories including effects on humans, effects on domestic animals and packaging failure. Incidents are further classified by severity, in the case of humans for instance, from minor effects such as skin rash, headache, etc., to major effects such as reproductive or developmental effects, life-threatening conditions or death.

The PMRA will examine incident reports and, where there are reasonable grounds to suggest that the health and environmental risks of the pesticide are no longer acceptable, appropriate measures will be taken, ranging from minor label changes to discontinuation of the product. Incident reports reflect the observations and opinion of the person reporting it and the Incident Reporting Program does not include validation of the reports. The PMRA collects incident reports in an effort to establish trends and the publishing of individual reports should not be considered as a statement of causality.

As of February 4th, 2009, there have been 8 human incident reports for malathion in Canada, all of which were classified as minor to moderate in nature and took place in residential areas. The majority of the reports (7 out of the 8) involved domestic class products that were typically applied by the homeowner with symptoms being reported by the applicator or a family member re-entering the treated area. The most common effect noted was dermal irritation (2 incidents), eye irritation (2 incidents), blurred vision (2 incidents, 1 with conjunctivitis), nasal irritation (1 incident), difficulties breathing (3 incidents), gastrointestinal upset (1 incident) and dizziness combined with general weakness (2 incidents). Although details were limited in some reports, malathion was not used according to label requirements in at least one reported incident. Causality has not been established for the effects noted in the incident reports, however, the effects are consistent with overexposure to an organophosphate known to cause irritation.

In the EPA Re-registration Eligibility Decision Document (2006), the EPA indicated that exposure to malathion was determined to be the primary cause in 55 reports documented in California between 1999 and 2003. Of the 55 cases, 5 cases were from agricultural application and 3 cases were attempted suicides. The EPA noted there has been a notable decrease in residential incidents, although the reason for the decline was uncertain. Symptoms most commonly reported included those associated with organophosphate poisoning, in particular headache, nausea, dizziness, muscle weakness, drowsiness, difficulties breathing, diarrhea, excess sensations, agitation, confusion, and blurred vision.

4.0 Impact on the Environment

The environmental risk assessment was conducted for commercial agricultural uses of malathion. Malathion uses registered for spot treatments (or dial-a-spray application) to control insect pests, such as for all domestic class products, were not considered. Exposure to the environment from these types of applications is expected to be mitigated owing to the small, confined areas that would be treated. The PMRA, therefore does not consider these applications to pose any unacceptable environmental risk.

Malathion applied as a mosquito adulticide for use in outdoor residential areas has been addressed in the Proposed Acceptability for Continuing Registration document PACR2003-10; as a result it will not be addressed here.

Commercial class products are applied by aircraft or ground application using traditional applications or by ultra-low volume (ULV) applications. This assessment addresses the environmental risk posed by non-ULV commercial agricultural application rates of malathion. With respect to ULV applications, it was stated in PACR2003-10 that adverse effects on the environment would be limited for the following reasons. Malathion degrades rapidly in the environment (half-life in soil < 1 day, water 0.3 – 19 days, foliage 5.5 days). The toxicity to birds and mammals is low and in view of the short lived nature of malathion in the environment, the risk to these organisms is limited. The impact to aquatic organisms will be limited in view of the ULV method of spray application. The droplets of pesticide are very small and do not drift or deposit like larger droplets. Spray droplets may evaporate during the period of suspension in the air, and so, not deposit at all. Therefore, deposit into aquatic systems from these type of application is reduced, exposure is minimized and adverse effects are, as a result, limited. It should be noted, however, that malathion applied by ULV for agricultural uses will pose a risk to beneficial insects, such as honey bees and other non-target arthropods. To mitigate exposure to bees and beneficial insects, precautionary statements will be added to the label.

4.1 Fate and Behaviour in the Environment

Based on its physical properties, malathion is very soluble in water (145 mg/L) and has a low potential to volatilize from moist soil or water surfaces (Henry's law constant = 1.2×10^{-7} atm m³/mole). Laboratory volatility studies confirm that malathion does not undergo any appreciable volatilization (for example, no more than 5.1% of the applied radioactivity volatilized during a 16 day study). Malathion, however, has been detected at low concentrations in ambient air samples from areas where it is used; the exposure and effects to non-target organisms, albeit unknown, is expected to be minimal. Malathion readily hydrolyses under neutral and alkaline conditions and is increasingly stable under acidic conditions and at low temperature. Phototransformation of malathion in soil and water is limited, however, it has been shown to be an important route of transformation in some natural waters containing photosensitizing agents. Although, the n-octanol-water partition coefficient ($\log K_{ow} = 2.75 - 2.94$) indicates the potential for bioaccumulation, laboratory studies show bioaccumulation in fish to be low.

In terrestrial environments, malathion is expected to biotransform rapidly ($DT_{50} = 0.2$ to 2 days). Hydrolysis may also contribute to the dissipation of malathion particularly under neutral to alkaline conditions ($DT_{50} = 6.2$ days, 36 and 12 hours at pH 7, 8 and 9, respectively). Mono- and dicarboxylic acid of malathion, identified as major transformation products in soil under laboratory conditions, are expected to be non-persistent ($DT_{50} = 2.8$ to 17.3 hours and 1.2 to 5.3 days, respectively). Malaoxon, the oxidation transformation product, is non-persistent under aerobic soil conditions ($DT_{50} = 6.5$ days at pH 6.2 and 3.5 days at pH 8.2); malaoxon is expected to hydrolyze readily under neutral and alkaline conditions but is increasingly stable under acidic conditions.

The USEPA RED (2006) for malathion reported foliar half-life estimates from 37 reports of malathion residue samples collected on 12 different crops by various researchers from 1957 to 1981. An assumed 90th percentile foliar dissipation half-life of 5.5 d on plant surfaces was derived. Malathion, therefore, is expected to be non-persistent on plant foliage.

Adsorption data show malathion to be moderately mobile in a variety of soils and that adsorption is positively correlated with soil organic carbon content. Malaoxon was detected in leachate and soil extracts and may also be mobile. The transformation products demethyl monocarboxylic acid and mono-carboxylic acid are expected to be highly mobile, particularly in alkaline soils. Malathion residues, therefore, may have the potential to reach groundwater. The leaching assessment using groundwater ubiquity score (GUS)¹, however, indicates that malathion is a non leacher and malathion does not satisfy all of the criteria set out by Cohen². Groundwater modelling, which utilized a scenario that would result in the conservative estimation of leaching, also indicated that malathion does not reach groundwater. No Canadian or ecoregion equivalent U.S. terrestrial field dissipation studies are available. Based on studies conducted in Georgia and California, malathion is shown to dissipate quickly under field conditions (<1 day). In the field dissipation study conducted in California, malathion was detected below a depth of 30 cm indicating that there is a potential for malathion to leach to groundwater. The short persistence of malathion is expected to reduce the risk of leaching to groundwater. Although Canadian monitoring data is limited, malathion detections are reported in well water and surface water samples, albeit infrequently and at very low concentrations.

Biotic transformation of malathion in the aquatic environment ranges from it being non-persistent to slightly persistent under aerobic conditions ($DT_{50} = 0.3 - 19$ days) with dissipation generally being fastest in alkaline systems, conditions that have been shown to favour rapid hydrolysis. In anaerobic aquatic systems, malathion is expected to be non-persistent in anaerobic systems ($DT_{50} = 2.5$ days in flooded soil). Laboratory results indicate that photolysis may also contribute to the dissipation of malathion from the water layer in the photic zone due to the presence of sensitizing agents in natural waters ($DT_{50} = 16$ hours in coloured river water, 8 days

¹ Gustafson, D.I. (1989) Groundwater Ubiquity Score: A Simple Method for Assessing Pesticide Leachability. *Environ. Toxicol. Chem.* 8:339 - 357.

² Cohen, S.Z., S.M. Crecger, R.F. Carsla and C.G. Enfield (1984) Potential for Pesticide Contamination of Groundwater Resulting from Agricultural Uses. *In* R.F. Druggier and J.N. Seiber, eds., *Treatment and disposal of Pesticide Wastes*. ACS symposium Series No. 259. American Chemical Society, Washington, DC, pp.297 - 325.

in filtered river water). Estimated DT_{50} s for malathion under aquatic field conditions (outdoor pond enclosures; 0.8–2.3 days) are comparable to those determined from laboratory aquatic studies. Because aquatic biotransformation studies for malathion (laboratory and field) were available only for alkaline conditions ($pH > 7$), which favour hydrolysis, a quantitative assessment of malathion fate and persistence under acidic conditions could not be conducted.

Three major transformation products, mono and dicarboxylic acid of malathion, and demethyl mono acid were identified in laboratory aerobic aquatic biotransformation studies. Under laboratory anaerobic conditions in flooded soil mono and di-carboxylic acid of malathion, demethyl mono and di-carboxylic acid of malathion were identified. Malathion and its major transformation products were predominantly present in the water phase of aerobic and anaerobic aquatic systems. Mono carboxylic acid of malathion is expected to be non-persistent under aerobic aquatic conditions ($DT_{50} = 3$ and 11 days, respectively); dicarboxylic acid of malathion is expected to be non-persistent to slightly persistent ($DT_{50} = 13$ –21 days). Dissipation times for other major transformation products were not available.

Environmental fate data for malathion are summarized in Appendix IX.

4.2 Environmental Risk Characterization

The environmental risk assessment integrates the environmental exposure and ecotoxicology information to estimate the potential for adverse effects on non-target species. This integration is achieved by comparing exposure concentrations with concentrations at which adverse effects occur. Estimated environmental exposure concentrations (EECs) are concentrations of pesticide in various environmental media, such as food, water, soil and air. The EECs are estimated using standard models which take into consideration the application rate(s), chemical properties and environmental fate properties, including the dissipation of the pesticide between applications. Ecotoxicology information includes acute and chronic toxicity data for various organisms or groups of organisms from both terrestrial and aquatic habitats including invertebrates, vertebrates, and plants. Toxicity endpoints used in risk assessments may be adjusted to account for potential differences in species sensitivity as well as varying protection goals (such as protection at the community, population, or individual level).

Initially, a screening level risk assessment is performed to identify pesticides and/or specific uses that do not pose a risk to non-target organisms, and to identify those groups of organisms for which there may be a potential risk. The screening level risk assessment uses simple methods, conservative exposure scenarios (for example, direct application at a maximum cumulative application rate) and sensitive toxicity endpoints. A risk quotient (RQ) is calculated by dividing the exposure estimate by an appropriate toxicity value ($RQ = \text{exposure/toxicity}$), and the risk quotient is then compared to the level of concern ($LOC = 1$). If the screening level risk quotient is below the level of concern, the risk is considered negligible and no further risk characterization is necessary. If the screening level risk quotient is equal to or greater than the level of concern, then a refined risk assessment is performed to further characterize the risk. A refined assessment takes into consideration more realistic exposure scenarios (such as drift to non-target habitats) and might consider different toxicity endpoints. Refinements may include further characterization of risk based on exposure modelling, monitoring data, results from field

or mesocosm studies, and probabilistic risk assessment methods. Refinements to the risk assessment may continue until the risk is adequately characterized or no further refinements are possible.

4.2.1 Risks to Terrestrial Organisms

A risk assessment of malathion to terrestrial organisms was based upon an evaluation of toxicity data for the following:

- Two earthworm species, one bee species (acute contact exposure)
- seven bird and two mammal species representing vertebrates (acute, dietary, reproduction exposure)

A summary of terrestrial toxicity data for malathion is presented in Appendix X. For the assessment of risk, toxicity endpoints chosen from the most sensitive species were used as surrogates for the wide range of species that can be potentially exposed following treatment with malathion. The terrestrial assessment took into account the range of agricultural application rates that are registered for malathion, taking into consideration that there may be multiple applications of malathion in a use season.

Terrestrial Invertebrates

The screening level risk assessment from malathion to terrestrial invertebrates is summarized in Appendix XI. The riskquotients for the screening level show that the level of concern (LOC) is not exceeded for acute effects to earthworms over the range of malathion application rates. Malathion, therefore is not expected to pose a risk to earthworms.

Honey bees are important pollinators and they can be exposed to malathion from direct application or contact with treated plant material. Malathion is highly toxic to honey bees according to the classification of Atkins et al (1981)³ with acute contact LD₅₀s ranging from 0.2 to 1.6 µg a.i./bee. Risk quotients for all agricultural use rates (RQ = 2 to 18), exceed the LOC for acute effects to bees. Mitigation (for example, precautionary label statements) is required for protection of honey bees.

Although no laboratory data were available for the toxicity of malathion to predatory and parasitic beneficial insects, reports of field observations of insect mortalities, related to spray programs conducted with malathion in the U.S., show that malathion is also toxic (contaminated pollen and direct contact) to non-target insects, such as lacewings (Neuroptera: Planipennia), stoneflies (Plecoptera), flies (Dipterids), lepidoptera (butterflies and moths), spiders (Arachnida), *cynipoidea* (parasitic Hymenoptera), and hemiptera (true bugs). Mitigation (for example, precautionary label statements), therefore, is required for the protection of beneficial insects.

³ Atkins EL; Kellum D; Atkins KW. 1981. Reducing pesticide hazards to honey bees: mortality prediction techniques and integrated management techniques. Univ Calif, Div Agric Sci, Leaflet 2883. 22 pp.

Terrestrial Plants

Data regarding the toxicity of malathion to non-target terrestrial plants (vegetative vigour, seed germination and emergence) were not available. Malathion is not expected to pose a risk to terrestrial plants as the mode of action (nervous system, such as acetylcholinesterase inhibition) does not apply to plants. Malathion is registered for pest control on a variety of plant species at a wide range of application rates; no incidents have been reported in the U.S. or Canada that indicate that malathion use causes adverse effects to terrestrial vascular plants.

Terrestrial Vertebrates

Wild birds and mammals may be exposed to residues of malathion as a result of sprayed vegetation and/or contaminated prey. For birds, the most sensitive endpoints from avian acute, dietary and reproductive studies were chosen for the screening level risk assessment; the acute and dietary LD₅₀ for the ring-necked pheasant (167 and 156 mg a.i./kg bw/day, respectively), and the reproductive NOAEL of 11.7 mg a.i./kg bw/day based on regressed ovaries and reduced egg hatch in Northern Bobwhite quail. For mammals, the most sensitive endpoints from mammalian acute and reproductive toxicity studies were chosen for the screening level risk assessment; the acute LD₅₀ for the Wistar rat (1580 mg a.i./kg bw/day), and the reproductive NOAEL of 394 mg a.i./kg bw/day based on reduced bodyweight in male Sprague-Dawley rat offspring. In dietary exposure studies, no treatment related or biologically significant mortality was observed for any of the concentrations tested; as such, an assessment of dietary risk to mammals was not conducted. To address uncertainties such as differences in species sensitivity as well as varying protection levels (for example, community, population, individual), the acute oral and dietary LD₅₀'s were divided by a factor of 10.

Standard exposure scenarios on vegetation and other food sources based on correlations in Hoerger and Kenaga (1972)⁴ and Kenaga (1973)⁵ and modified according to Fletcher *et al.* (1994)⁶ were used to determine the concentration of pesticide in the diet of small wild birds and mammals. Exposure is dependent on the body weight of the organism and the amount and type of food consumed. In the screening level assessment a set of generic body weights was used for birds and mammals (20, 100 and 1000g, and 15, 35, 1000 g, respectively) to represent a range of small wild bird and small mammal species. It is noted that diets of animals can be highly variable from season to season as well as day to day. Furthermore, animals are often opportunists and if they encounter an abundant and/or desirable food source, they may consume large quantities of that food. For these reasons, the screening level assessment used relevant food categories for each size group consisting of 100% of a particular dietary item. These items included the most conservative residue values for plants, grains/seeds, insects, and fruits. As no

⁴ Hoerger F; Kenaga EE. 1972. Pesticide residues on plants: correlation of representative data as basis for estimation of their magnitude in the environment. In: Coulston F; Korte F. (eds). Global aspects of chemistry, toxicology and technology as applied to the environment, Vol. I. Thieme, Stuttgart, and Academic Press, New York. pp. 9-28.

⁵ Kenaga EE. 1973. Factors to be considered in the evaluation of the toxicity of pesticides to birds in their environment. In: Coulston F; Dote F. (eds). Global aspects of chemistry, toxicology and technology as applied to the environment, Vol. II. Thieme, Stuttgart, and Academic Press, New York. pp. 166-181.

⁶ Fletcher, J.S., Nellessen, J.E., and Pfleger, T.G. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, an instrument for estimating pesticide residues on plants. Environmental Toxicology and Chemistry 13:1383-1391.

small birds or mammals in North America are known to eat a diet primarily of leafy plant material or grass, estimated daily exposures (EDEs) for small birds (20 and 100 g) and mammals (15 g) based on a 100% diet of plants were not calculated. EDEs were calculated for each bird and mammal size and feeding preference item at the lowest single malathion application rate (425 g ai/ha), a single medium range application rate (1376.5 g ai/ha) and the highest cumulative application rate (3952.5 g ai/ha x 2 applications with a 10 day interval between applications); the cumulative application rate was estimated using a foliar half-life of 5.5 days.

The screening level risk assessment for malathion to birds and mammals is summarized in Appendix XII. The risk quotients show that the LOC is exceeded for all effects in several generic bird weight and food preference categories, over the full range of agricultural application rates (RQ = 1.0–34). For mammals, the risk quotients show that single malathion applications in the low to medium application range (425–1376.5 g ai/ha) do not exceed the LOC for effects in all mammal size and feeding preference categories, with the exception of acute effects for 35g mammals feeding exclusively on leaves and leafy crops (RQ = 1.5). At the highest cumulative application rate, the LOC is exceeded for acute and reproductive effects in 35g mammals (RQ = 1.8–5.5 and 1.1–2.2, respectively) and 1000g mammals for acute and reproductive effects (RQ = 1.4–2.9 and 1.2, respectively) feeding on some plant items.

Given the conservative assumption taken in the screening level assessment a refined assessment was conducted to further characterize the risk to birds and mammals. Acute and dietary toxicity endpoints were available for 5 and 4 species of birds, respectively. The risk assessment for acute and dietary effects was refined by fitting separate species sensitivity distribution for the acute and dietary LD₅₀ data. The 5th percentile of the species sensitive distribution (HD₅) for the LD₅₀ was calculated; choosing the 5th percentile of the species sensitivity distribution means that for 95% of species, the chemical is expected to be less toxic than the estimated 5th percentile toxicity value and for 5% of species, the chemical may be more toxic than the estimated 5th percentile toxicity value. The acute and dietary HD₅ calculated was 87.6 and 111.7 mg ai/kg bw/day. The reproductive risk to birds was assessed by taking the geometric mean of the two available toxicity endpoints (NOAEL for Northern bobwhite quail and Mallard duck); 27.8 mg ai/kg bw/day. For mammals, the acute risk was assessed by taking the geometric mean of the two endpoints available for the Wistar rat (3560 mg ai/kg bw/day), which was the most sensitive species. As only one study was available with a reproductive endpoint (394 mg ai/kg bw/day, based on reduced body weight in male Sprague Dawley rat offspring), no further endpoint refinement for reproductive effects was possible.

The refined risk assessment used the mean residue values on terrestrial food sources for calculating EECs and EDEs instead of the upper bound residue values used in the screening risk assessment. The EDEs for birds and mammals feeding on treated fields were calculated for each bird and mammal size and feeding preference item using the same application rates that were used at the screening level (425, 1376.5 and 3952.5 g ai/ha).

The risk associated with the consumption of food items contaminated from spray drift off the treated field was also assessed. The spray drift data of Wolfe and Caldwell (2001)⁷ was used to determine that the maximum amount of spray deposited into a habitat adjacent to a field sprayed using ground boom equipment. The maximum amount of spray that is expected to deposit 1m downwind from the application site during spraying using ground boom equipment and a coarse droplet size (ASAE) will not exceed 3%. Similarly, it was estimated from the data of Ganzelmeier et al. (1995)⁸ that the maximum amount of spray deposited into a habitat adjacent to an orchard sprayed using airblast equipment will not exceed 74% of the applied application rate for early applications and 59% of the applied application rate for late applications. Aerial application spray drift was determined through model simulations using AGDISP v. 8.15; the maximum amount of spray that is expected to deposit 1m downwind from the application site during aerial spraying and a coarse droplet size (ASAE) will not exceed 17%. This information was used to determine the risk to birds and small mammals consuming contaminated food items in terrestrial habitats adjacent to sites where malathion was applied. Given the variation in percent drift off site for each of the application methods, the assessment of potential risk from drift considered the maximum cumulative application rates as listed on the labels specific to field sprayer, aerial and airblast application rates, 1376.5 g ai/ha (x4, 3d interval), 1376.5 g ai/ha (2x, 14d interval), and 3952.5 (2x, 10d interval), respectively. The application rates, representative of off-field drift, for each of the three application methods are: field sprayer – 102 g ai/ha; aerial – 274 g ai/ha; 3754 ga ai/ha for early airblast. Off-field risk quotients for field sprayer and aerial applications were calculated only for bird class sizes and feeding preferences that showed risk in the on-field assessment at 1376.5 g ai/ha; risk quotients for airblast applications were calculated for bird class sizes and feeding preferences that showed risk at the highest application rate for the on-field assessment (3952.5 g ai/ha – 2x, 10d interval).

Risk quotients were calculated only for the bird and mammal class sizes and feeding preferences that showed risk in the initial screening level assessment. In addition, for RQs exceeding the LOC, two additional parameters were calculated to assess the relevance of the determined risk: 1) the percent daily diet required to reach the LOC (calculated as $1/RQ \times 100$), and 2) the number of days that residues remain on food items above the LOC; (calculations based on a foliar half-life of 5.5 days). As the assessment cannot account for loss of residues from food sources from washoff during rain events, the estimated number of days that residues remain on food items above the LOC is considered conservative.

⁷ Wolf, T and B.C. Caldwell, 2001. Development of a Canadian spray drift model for the determination of buffer zone distances. *In* Expert Committee on Weeds, Proceedings of the 2001 National Meeting, Quebec City, Sainte Anne de Bellevue, Quebec: ECW-CEM. D. Bernier, DRA Campbell, D. Cloutier, Eds

⁸ Ganzelmeier, H; Rautmann, D; Spangenberg, R; Strelake, M; Herrmann, M; Wenzelburger, H-J; Walter, H-F 1995. Studies on the spray drift of plant protection products: Results of a test program carried out throughout the Federal Republic of Germany. Report Number 305 from the Biologischen Bundesanstalt für Land-und Forstwirtschaft, Berlin-Dahlem. Blackwell Wissenschafts-Verlag GmbH, Berlin/Vienna.

The risk to birds feeding on-field and off-field based on mean residue values on terrestrial food sources is characterized in Appendix XIII and XIV, respectively. The risk quotients indicate that malathion applications at the lowest crop application rate (425 g ai/ha) do not pose a risk to birds. For the medium single application rate (1376.5 g ai/ha), the LOC for reproductive effects is exceeded for 20 and 100g insectivores and 1000g herbivores feeding on leafy foliage on field. At the highest application rate (3952 g ai/ha x2, 10 d interval), the on-field assessment shows that the LOC is exceeded for all effects on 20g insectivores, reproductive effects in 20g granivores, acute and reproductive effects in 100g insectivores, reproductive effects in 20 and 100g frugivores and for all effects in 1000g herbivores; for birds feeding off-field, the LOC is exceeded for the same effects, bird size and feeding guilds, with the exception of reproductive effects in 20g granivores.

In some cases, although an exposure risk is identified, the risk is unlikely to manifest in birds feeding either on or off-field because: 1) birds would need to consume an unrealistically large proportion of a single food item (for example, 92% diet of grain and seeds for reproductive effects in 100g birds feeding on fields treated at highest cumulative crop application rate), and 2) residue levels remaining on food items above the LOC are expected to be short lived (for example, 1 day or less). In other cases, however, the proportion of a single food item required to reach the LOC is relatively low (for example, 21% for reproductive effects in 1000g birds feeding on leaves and leafy crops treated at the highest cumulative application rate) and birds and mammals may be exposed to residue levels remaining on food items above the LOC for relatively long time periods (for example, 23 days). Overall, the results of the refined avian risk assessment indicate that malathion may pose a risk to birds feeding exclusively on fields treated at the single medium to highest cumulative range of application rates and also adjacent to field sites sprayed using airblast equipment. The refined mammalian risk assessment is characterized in Appendix XV; the risk quotients indicate that malathion does not pose a risk to mammals.

4.2.2 Risks to Aquatic Organisms

A risk assessment of malathion to aquatic organisms was based upon an evaluation of toxicity data for the following:

- eighteen freshwater invertebrate species (acute and chronic exposure)
- eighteen freshwater fish species (acute and chronic exposure)
- two amphibian species (acute)
- four estuarine/marine invertebrate species (acute and chronic exposure)
- five estuarine/marine fish species (acute and chronic exposure)

A summary of aquatic toxicity data for malathion is presented in Appendix X.

No data have been submitted by the registrant regarding the toxicity of malathion to non-target aquatic vascular plants or algae, nor were any relevant studies found in the open literature. Malathion is not expected to pose a risk to aquatic vascular plants or algae because the mode of action does not apply to these organisms. No incidents have been reported that indicate that malathion use causes adverse effects to aquatic vascular plants or algae.

Screening level assessment

For the initial conservative screening level assessment, EECs for aquatic systems were calculated based on the lowest single application rate (425 g ai/ha) directly applied to water bodies with a depth of 15 cm (seasonal water body for amphibian endpoints) and 80 cm (permanent water body for remaining endpoints), as well as at the highest cumulative application rate (3953.5 g ai/ha, x2, 10 day interval) at the same water depths. The aquatic EEC for the highest cumulative application rate was estimated by adjusting the sum of the applications for dissipation between applications using a DT_{50} in water of 19 d, which is the most conservative value reported from the aerobic aquatic biotransformation studies. For the assessment of risk, toxicity endpoints chosen from the most sensitive species tested were used as surrogates for the wide range of species that can be potentially exposed following treatment with malathion. The endpoints were derived by dividing the EC_{50} or LC_{50} from the appropriate laboratory study by a factor of two (2) for aquatic invertebrates, and by a factor of 10 for fish and amphibians. In order to assess the risk to amphibians for a chronic exposure to malathion, the endpoint value for the most sensitive fish was used as surrogate data.

The screening level risk assessment for malathion to aquatic organisms is summarized in Appendix XVI. The risk quotients indicate that malathion may potentially pose an acute and chronic risk to all freshwater aquatic organisms ($RQ = 14\text{--}3360$ and $7.4\text{--}14000$, respectively) and estuarine/marine aquatic organisms ($RQ = 16\text{--}764$ and $6\text{--}93$, respectively).

Refined Risk Assessment for Aquatic Organisms

Given the conservative assumption taken in the screening level assessment (such as direct application to a water body), a refined assessment was conducted to better characterize the risk to aquatic organisms. Sufficient acute toxicity data was available for both freshwater invertebrates, freshwater and estuarine/marine fish, and chronic toxicity data for fish only, to determine HC5s. The acute HC5 for freshwater invertebrates, freshwater and estuarine/marine fish are 0.13 and 7.5 and 31.3 $\mu\text{g ai/L}$, respectively and the chronic HC5 for freshwater fish is 2.0 $\mu\text{g ai/L}$; these endpoints were used for the refined risk assessment.

Spray drift refinement

Similar to the terrestrial risk assessment, the risk to aquatic organisms from spray drift off the treated site was also assessed taking into consideration the spray drift deposition of spray quality of ASAE coarse for ground boom (3%), aerial (17%) and airblast (74% early season and 59% late season at 1 m downwind from the site of application). Given the variation in percent drift off site for each of the application methods, the assessment of potential risk from drift was assessed for the minimum single and maximum cumulative application rates as listed on the labels specific to each of the three application methods. The minimum single and maximum cumulative application rates for field sprayers, aerial and airblast application range from 527–1376.5g ai/ha (x4, 3d interval), 425–1376 g ai/ha (2x, 14d interval) and 625–3952.5 g ai/ha (x2, 10d interval), respectively. Cumulative EECs for commercial application rates were estimated by adjusting the sum of the applications for dissipation between applications using the 80th percentile of aerobic aquatic biotransformation half-lives (8.25 days). Using the percentages for off-site drift to non-target aquatic habitats, the off-site EECs for malathion using the application methods of field sprayers, aerial, early and late airblast would range between 2–5 mg ai/L, 9–38 mg ai/L, 57–523 mg ai/L and 46–417 mg ai/L, respectively.

The risk to aquatic organisms resulting from spray drift is summarized in Appendix XVI. The risk quotients indicate that the LOC is exceeded for all organisms and all application methods on an acute basis (RQs = 1.0 to 4023), with the exception of freshwater and estuarine/marine fish at the lowest field sprayer application rate, and estuarine marine fish at the lowest aerial application rate. Amphibians at the lowest field sprayer application rate and marine estuarine fish at the highest field sprayer application rate were also shown to be not at risk. On a chronic basis, the RQs indicate that the LOC is exceeded for invertebrates, freshwater fish and amphibians for all application methods (RQ = 1.0–8717). Chronic RQs for estuarine/marine fish exceed the LOC for all application methods (1.0–58), with the exception of the lowest field sprayer application rate. In order to reduce the potential risk to aquatic species, buffer zones are required.

Runoff Refinement

Aquatic organisms can also be exposed to malathion from foliar applications as a result of runoff into a body of water. The linked models PRZM (Pesticide Root Zone Model) and EXAMS (Exposure Analysis Modeling System) were used to predict estimated environmental concentrations (EECs) resulting from runoff of malathion following application. The models were run at the lowest single rate (to assess risk at the lowest possible use rate) and the highest cumulative rate (to cap the highest risk possible): the lowest single application rate is for use on canola at 0.425 kg ai/ha; the highest seasonal application rate is for use on apples at 3.952 kg ai/ha applied twice a year with a 10 day interval (seasonal maximum of 7.904 kg ai/ha).

The malathion EECs in a 1-ha receiving water body (80 and 15 cm deep) predicted by PRZM-EXAMS at the lowest and highest application rate are presented in Table 1. The values reported by PRZM/EXAMS are 90th percentile concentrations of the concentrations determined at a number of time-frames including the yearly peak, 96-hr, 21-d, 60-d, 90-d and yearly average.

Table 1 PRZM/EXAMS runoff modelling results ($\mu\text{g a.i./L}$) for malathion in water bodies 0.8 m and 0.15 m deep, excluding spray drift.

Depth of water body	Peak	96 hr	21 d	60 d	90 d	Yearly
Lowest single application rate: 1 x 0.425 kg ai/ha on canola						
15 cm	2.7	1.7	0.58	0.25	0.17	0.045
80 cm	0.51	0.37	0.14	0.06	0.04	0.009
Maximum seasonal application rate: 2 x 3.952 kg ai/ha on apples						
15 cm	52.05	33.03	12.32	5.27	3.72	0.96
80 cm	9.82	7.04	2.96	1.14	0.77	0.19

The toxicology endpoints used in the refined drift assessments were used to calculate risk quotients to determine the risk from runoff to aquatic organisms in habitats adjacent to the site of malathion applications. Acute RQ values were calculated using the yearly peak EEC value where appropriate. The EEC's with the appropriate time periods were used to calculate the risk quotients, for example, yearly peak EEC for acute endpoints and 21-day for chronic endpoints.

The refined risk assessment to aquatic organisms from malathion runoff is summarized in Appendix XVIII. The RQs derived for acute exposure exceed the LOC in freshwater invertebrates at all malathion application rates (RQ = 3.9–76). For freshwater fish, amphibians and estuarine and marine invertebrates, the RQs exceed the LOC for acute effects at the highest malathion application rate only (RQ = 1.3–8.9). The RQs derived for chronic exposure indicate that the LOC is not exceeded for aquatic organisms except for freshwater invertebrates (RQ = 2.3–49) at all application rates, and amphibians (RQ = 6.2) at the highest application rate only.

Surface Water Monitoring Data Risk Assessment

There was malathion monitoring data available that is representative of several different use patterns related to malathion-containing end-use products (Appendix XX, Table 2). The risk assessment was refined by considering all available Canadian monitoring data. An acute EEC of 1.6 ug/L (95th percentile of the maximum detected concentration from surface water monitoring studies) and a chronic EEC of 0.1 ug/L (the 95th percentile of the mean concentration from each study site including ½ LOD for non-detects) was used for the refined risk assessment. The acute and chronic risk to aquatic organisms from the 95th percentile values for concentrations observed in surface water from monitoring data are presented in Appendix XIX.

The RQ values indicate that the LOC for acute effects is exceeded for freshwater and marine invertebrates (RQ = 12 and 1.5, respectively); the LOC for chronic effects is exceeded for freshwater invertebrates (RQ = 1.7). This analysis supports the runoff modeling aquatic risk assessment by showing that concentrations observed in Canadian surface waters from monitoring data could present a risk to freshwater and estuarine/marine invertebrates.

4.2.3 Incident reports / additional considerations

Since April 26, 2007, registrants have been required by law to report incidents, including adverse effects to health and the environment, to the PMRA within a set time frame. Information on the reporting of incidents can be found on the PMRA website <http://www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/incident/index-eng.php>.

As of June 20, 2009, the PMRA is not aware of any Canadian incident reports related to adverse effects on wildlife or natural vegetation from malathion. According to the USEPA's Ecological Incident Information System (EIIS) database, there are forty-two incidents reported for malathion of which thirteen are reported to be the result of registered use on crops occurring between 1973 and 1998. Of the thirteen incidents that resulted from registered use, nine incidents involved fish kills listed as possible to highly probable; four of the incidents reported the total number of fish killed which ranges from 16 to 350 fish per incident. The majority of the fish kill incidents are reported to have been the result of spray drift following aerial application to cotton

for the U.S. Boll Weevil Eradication Program. Cotton is not a crop relevant to the Canadian use pattern, nor is Boll weevil a pest of concern in Canada. The aerial application rate range registered for use on Canadian crops (425–1375 g a.i./ha), however, is similar to that used in the U.S. Boll Weevil Eradication Program (336–1367g a.i./ha).

The remaining three incidents involved terrestrial organisms; two reported bee kills and one reported bird deaths. Drift of malathion after ULV application to alfalfa is considered a possible cause for one of the bee kill incidents; the method of application (ground versus air) was not reported. The second bee kill incident was the result of spray drift following aerial non-ULV application for the Boll Weevil Eradication Program to a cotton field located 50 feet from a bee apiary. Malathion was confirmed as the cause of the bee incident through residue analysis of dead bees and the incident is listed as highly probable. The bird incident involved the death of seventeen Western sandpipers after the application of temephos and malathion to control mosquitos; of these two insecticides, temephos was considered to be the more probable cause due to its greater toxicity to birds than malathion.

The information in the incidents is consistent with the known toxicity hazard of malathion to terrestrial and aquatic organisms. The incident reports did not impact the risk assessment.

5.0 Value

5.1 Commercial and Restricted Class Products

Appendix I lists all malathion products registered in Canada as of April 10, 2008. Appendix IIa lists all the Commercial and Restricted Class product uses for which malathion is presently registered and shows which uses the registrant will continue to support or will no longer support. Also presented in Appendix IIa is whether the use was added through the PMRA Minor Use Program. While currently supported by the registrant, the data supporting the minor uses were originally generated by a user group.

Malathion is used to control a broad range of insect pests on a wide variety of sites including:

- aquatic non-food sites;
- empty food storage areas;
- greenhouse (food and non-food crops);
- human habitat and recreational areas;
- industrial oilseed and fibre crops;
- livestock for food;
- seed treatment;
- stored food and feed;
- structural sites;
- terrestrial feed and food crops;
- outdoor ornamentals; and
- residential outdoor sites.

Appendix XXI lists those uses of malathion that the registrant continues to support as well as uses that are not supported. The PMRA welcomes feedback on the availability and extent of use of chemical alternatives to malathion for the uses listed in Appendix XXI and information regarding the availability, effectiveness and extent of use of non-chemical pest management practices for any of the registered uses of malathion. This information will allow the PMRA to refine sustainable pest management options for the listed site-pest combinations.

5.2 Domestic Class Products

Domestic Class uses of malathion which are supported by the registrant are listed in Appendices IIb and IIc.

5.3 Value of Malathion

5.3.1 Spectrum of Malathion Use; Pests

In Canada, malathion is registered for use on a wide range of pests from families and groupings including: Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera and Orthoptera and other chewing and sucking insects and ectoparasites (Diptera, Acari, Mallophaga).

5.3.2 Agricultural Uses of Malathion

5.3.2.1 Malathion for the control of a wide variety of chewing pests

Malathion is a non-systemic insecticide and acaricide with contact, stomach, and respiratory action. Malathion is suited for control of a wide variety of chewing insects. Chewing insects, in general, are non-selective in their feeding behaviours as they typically ingest macerated whole-leaf tissue. Insecticides with stomach-poison activity are more effective in controlling insects with chewing mouthparts.

5.3.2.2 IPM compatibility and short pre-harvest interval

Malathion is relatively soft on beneficial arthropods including mite predators and because of its short pre-harvest interval (PHI) it is frequently used in berry production. Many insects are present on berry plant foliage and during harvesting they can contaminate the harvested product, thus, insecticides with a short PHI are needed as a "clean-up" spray. Malathion has a one day PHI on blueberry and raspberry and a three day PHI on cranberry, currant, gooseberry and strawberry. Malathion can be used under these circumstances to control insects such as aphids, weevils, beetles and caterpillars.

5.3.2.3 User Requested Minor Use Label Expansions - Uses with few viable alternative active ingredients or no registered alternatives

Malathion has several uses that were registered through the User Requested Minor Use Label Expansion (URMULE) program including:

- control of grasshoppers on lentil; registered alternatives include chlorpyrifos, deltamethrin and lambda-cyhalothrin;
- control of multicoloured Asian lady beetle on grape; cypermethrin is the only registered alternative;
- control of aphids on canary seed; dimethoate is the only registered alternative;
- control of sciarid and phorid flies on mushrooms; registered alternatives include diazinon, dichlorvos, permethrin and pyrethrins. Cyromazine and methoprene are registered to control sciarid flies only; and
- control of wild riceworm on wild rice; malathion is the only registered insecticide.

5.3.2.4 Uses of malathion identified as having value in crop profiles

In Canada, crop profiles are documents that provide crop production and pest management information on a commodity basis. Crop profiles prepared by Agriculture and Agri-Food Canada are developed through an extensive consultative process and are reviewed by industry and provincial specialists. Malathion is used on a wide range of crops to control a broad range of pests.

For some of the malathion uses identified in crop profiles, there are few if any other registered alternatives such as:

- on blackberry diazinon is the only other active ingredient registered to control thrips but is no longer a viable alternative as it is being phased out (RVD 2009-18).
- on highbush blueberry malathion is the only insecticide registered for control of strawberry root weevil adults (BC only). Also, permethrin is the only alternative to control thrips during the vegetative year, while malathion is the only product for use during the harvest year;
- on grapes endosulfan, which is also under re-evaluation, is the only alternative for control of grape phylloxera (leaf form in Ontario);
- on raspberries diazinon is no longer a viable alternative for control of raspberry fruitworm (pre-bloom) and thrips. Carbofuran, which is proposed for phase out, is the only alternative registered to control bud weevil; and
- on strawberry carbofuran is the only registered alternative for control of strawberry root weevil (BC only).

6.0 Pest Control Product Policy Considerations

6.1 Toxic Substances Management Policy Considerations

The Toxic Substances Management Policy (TSMP) is a federal government policy developed to provide direction on the management of substances of concern that are released into the environment. The TSMP calls for the virtual elimination of Track 1 substances [those that meet all four criteria outlined in the policy, such as, persistent (in air, soil, water and/or sediment), bio-accumulative, primarily a result of human activity and toxic as defined by the *Canadian Environmental Protection Act*].

During the review process, malathion and its transformation products were assessed in accordance with the PMRA Regulatory Directive DIR99-03⁹ and evaluated against the Track 1 criteria. The PMRA has reached the following conclusions:

- Malathion does not meet Track 1 criteria and will not form any transformation products which meet the Track 1 criteria. Malathion is not considered a Track 1 substance. See Table 2 for comparison with Track 1 criteria.

Table 2 Toxic Substances Management Policy Considerations-Comparison to TSMP Track 1 Criteria

TSMP Track 1 Criteria	TSMP Track 1 Criterion value		Active Ingredient Are criteria met?	Transformation Products (malaoxon) Are criteria met?
CEPA toxic or CEPA toxic equivalent*	Yes		Yes	Yes
Predominantly anthropogenic**	Yes		Yes	Yes
Persistent	Persistent in one of the following media:		Not persistent	Not persistent
	Soil	Half-life > 182 days	Half-life < 2 days	Half-life 3.5 – 7.5 days
	Water	Half-life > 182 days	Half-life 19 days	Not available
	Sediment	Half-life > 365 days	Half-life Not available	Not available

⁹ DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*

TSMP Track 1 Criteria	TSMP Track 1 Criterion value		Active Ingredient Are criteria met?	Transformation Products (malaoxon) Are criteria met?
	Air	Half-life > 2 days or evidence of long range transport	Half-life or volatilisation is not an important route of dissipation and long-range atmospheric transport is unlikely to occur based on the vapour pressure (1.25 x 10 ⁻⁶ mm Hg) and Henry's Law Constant (1.2 x 10 ⁻⁷ atm m ³ /mole).	Not available
Bioaccumulative	The log K _{OW} and/or BCF and/or BAF are preferred over log K _{OW} .		Not bioaccumulative	Not available
	Log K _{OW} ≥ 5		2.75 – 2.94	
	BCF ≥ 5000		7.36 – 29.3 in fish; 869 – 959 in shrimp	
	BAF ≥ 5000		not available	
Is the chemical a TSMP Track 1 substance (all four criteria must be met)?			No, does not meet TSMP Track 1 criteria.	No, does not meet TSMP Track 1 criteria.

* All pesticides will be considered CEPA-toxic or CEPA toxic equivalent for the purpose of initially assessing a pesticide against the TSMP criteria. Assessment of the CEPA toxicity criteria may be refined if required (such as, all other TSMP criteria are met).

** The policy considers a substance “predominantly anthropogenic” if, based on expert judgement, its concentration in the environment medium is largely due to human activity, rather than to natural sources or releases.

6.2 Formulants and Contaminants of Health or Environmental Concern

During the review process, contaminants in the technical and formulants and contaminants in the end-use products are compared against the *List of Pest control Product Formulants and Contaminants of Health or Environmental Concern* maintained in the *Canada Gazette*¹⁰. The list is used as described in the PMRA Notice of Intent NOI2005-01¹¹ and is based on existing policies and regulations including: DIR99-03; and DIR2006-02¹², and taking into consideration the Ozone-depleting Substance Regulations, 1998, of the *Canadian Environmental Protection Act* (substances designated under the Montreal Protocol). The PMRA has reached the following conclusions:

¹⁰ *Canada Gazette*, Part II, Volume 139, Number 24, SI/2005-114 (2005-11-30) pages 2641–2643; *List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern* and in the order amending this list in the *Canada Gazette*, Part II, Volume 142, Number 13, SI/2008-67 (2008-06-25) pages 1611–1613. *Part 1 Formulants of Health or Environmental Concern, Part 2 Formulants of Health or Environmental Concern that are Allergens Known to Cause Anaphylactic-Type Reactions and Part 3 Contaminants of Health or Environmental Concern.*

¹¹ NOI2005-01, *List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern under the New Pest Control Products Act.*

¹² DIR2006-02, PMRA Formulants Policy.

- Technical grade malathion and its end-use products do not contain any formulants or contaminants of health or environmental concern identified in the *Canada Gazette*.

7.0 Summary

7.1 Human Health and Safety

The toxicology database submitted for malathion is adequate to define the majority of toxic effects that may result from exposure to malathion. Malathion was not found to be genotoxic or teratogenic in animal studies. Malathion is unlikely to pose a carcinogenic risk to humans. Following administration to pregnant rabbits, an increase in resorptions (embryo-fetal loss) has been observed in the presence of maternal toxicity. Due to the nature of this endpoint and its potential implications on the health of the unborn child, extra protective measures were applied during the risk assessment to further reduce the allowable level of human exposure to malathion.

The target for malathion is the nervous system, including effects on neurobehavioural parameters and acetylcholinesterase inhibition. For animals exposed to malathion, erythrocyte cholinesterase (EChE) is the most sensitive compartment for effects on cholinesterase, with inhibition being observed in a variety of species and by all routes of exposure. Young animals showed greater sensitivity to these effects than adults. The risk assessment protects against these effects by ensuring that the level of human exposure is well below the lowest dose at which these effects occurred in animal tests.

7.1.1 Occupational Risk

Risk estimates associated with applying, mixing, and loading activities for agricultural label uses are not of concern, provided that engineering controls, personal protective equipment, and additional mitigation measures as listed in Section 8 and Appendix XXII are implemented.

Post-application risks for workers were not of concern when the proposed mitigation measures (REIs) are applied.

7.1.2 Dietary Risk from Food and Drinking water

Dietary risk estimates were evaluated using conservative assumptions to compensate for the toxicity of the mostly undetected malaoxon metabolite, and the general lack of data on magnitude of residues studies. Although acute and chronic dietary risk were found not of concern, confirmatory data is requested for magnitude of residues and metabolism, especially on residues arising from the direct treatment of livestock and applications to stored grains.

7.1.3 Residential Risk

Risks to homeowners applying malathion to their residential vegetable and fruit gardens, outdoor ornamentals, and foundations, exterior walls surfaces and under fences and shrub, is not of concern.

Non-occupational post-application risk is not of concern for adults and youths contacting treated vegetables and fruits, and outdoor ornamentals when proposed mitigation measures as listed in Section 8 and Appendix XXII are implemented. In addition, risk to adults, youths, and toddlers exposed to malathion following its use in mosquito abatement programs, is not of concern.

7.1. Aggregate Risk

Aggregate risk from combining food, drinking water, and exposure from residential uses, is not of concern. Exposures resulting from 'Pick Your Own' facilities are not of concern.

7.2 Environmental Risk

Malathion is non-persistent in soil and non-persistent to slightly persistent in water. As malathion is very soluble in water and does not adsorb strongly to soil, there is a potential that under appropriate environmental conditions that malathion residues may through runoff appear in surface water and/or leach into groundwater. Water monitoring data, although limited, show the detection of malathion in Canadian surface water and groundwater, albeit infrequently and at low concentrations.

In the terrestrial environment, at the current registered application rate and use patterns, malathion may pose a risk to bees and other pollinators, as well as beneficial predators and parasites, and birds. Effects in the terrestrial ecosystem are often difficult to mitigate due to the occurrence of non-target species in treated areas. Risk to bees may be reduced by restricting the application of malathion to periods when they are not actively foraging. For beneficial insects living in habitats adjacent to the application site, risk may be reduced by minimizing spray drift. Appropriate environmental hazard statements are included on product labels to mitigate the risk to bees and beneficial insects. For other terrestrial organisms such as birds, options are limited.

In the aquatic environment, run-off and drift may pose risks to freshwater and marine organisms. The risks identified from exposures via drift or run-off may be mitigated by applying spray buffer zones and label statements. Currently, no spray buffer zones are required for products containing malathion. To mitigate the environmental risk to aquatic organisms from off-target drift, the PMRA is proposing that Canadian commercial product labels stipulate an ASAE spray quality of coarse for all ground and aerial applications, and a wind speed restriction of 10km/hour for aerial applications. These restrictions yield the smallest spray buffer zones which could be expected to mitigate 100% of the risk to aquatic habitats from spray drift. The PMRA is seeking comments from stakeholders, growers etc. on the feasibility of some of the larger buffer zones proposed for aerial applications.

The PMRA has used a science-based approach to determine spray buffer zones for all new products registered. This approach uses empirical models that determine the proportion of drift/deposition that results in off-field exposure concentrations at which no unacceptable effects occur. The current assessment for freshwater invertebrates is based on a single chronic endpoint for one species. This approach is potentially overly conservative and could be refined with the submission of additional data that would allow for the use of a species sensitivity distribution (SSD) or more preferably a community NOEC (such as mesocosm studies conducted under appropriate conditions) that would assess impacts at the community level. Interested parties are invited to submit such data for consideration in refining the aquatic risk assessment for aquatic invertebrates. The PMRA strongly recommends that before any new mesocosm study is undertaken a test protocol be submitted for review.

It should also be noted that the PMRA has recently embarked on an initiative to re-examine and update its approaches to habitat protection. Consequently, the proposed mitigation measures for malathion may change when the PMRA's policy on habitat protection is finalized and/or if new data are submitted that allows the risk assessment to be refined.

8.0 Proposed Regulatory Decision

After a re-evaluation of the insecticide malathion, Health Canada's Pest Management Regulatory Agency (PMRA), under the authority of the *Pest Control Products Act*, is proposing continued registration of malathion products for sale and use in Canada provided that the mitigation measures to protect health and the environment and proposed label changes described in Appendix XXII of this document are implemented. Additional data are being requested to refine the risk assessment.

8.1 Proposed Regulatory Actions

8.1.1 Proposed Regulatory Action Related to Human Health

Overall acute and chronic dietary risks were not of concern. However, the PMRA has no or very limited data on residues arising from the direct treatment of livestock and applications to stored grains. Additional data on magnitude of residues and metabolism as per Section 12 of PCPA will be required to support continued registration of these uses.

The PMRA did not conduct post-application exposure assessment for mushroom houses or structural sites due to lack of data. In addition, there is a potential exposure to malaoxon on turf, and outdoor hard surfaces following application of malathion in mosquito abatement programs. Additional data as per Section 12 of PCPA will be required to support continued registration of these uses.

The PMRA found that isomalathion (impurity) concentrations in malathion lab samples have been shown to increase with temperature and time. A label statement for storage conditions is recommended to prevent isomalathion increase in the end-use products.

8.1.1.1 Toxicological Information

Specific label requirements are listed in Appendix XXII.

8.1.1.2 Proposed Measures to Protect Mixers/Loaders/Applicators and Workers Re-entering Treated Areas

Additional specific mitigation measures as label requirements are listed in Appendix XXII.

Wettable Powder in Water Soluble Packaging (WSP):

All malathion products currently formulated as wettable powders must be in water soluble packaging.

8.1.1.3 Residue Definition

The present residue definition (RD) in the Canada Gazette dated July 2008 names malathion *per se* as the only residue of concern. However, recent toxicological re-evaluation established the relative toxicity of malaoxon, a malathion metabolite, as 24 times that of the parent malathion. The risk to health associated with malaoxon can therefore be significant even if residues on commodities are, in most cases, undetectable. In an effort to regulate and perform risk assessment on the most practical terminal residue while reducing regulatory burden, malathion *per se* is reaffirmed as the residue definition by PMRA because malaoxon residues can be conservatively estimated from LOD of analytical methods. The proposed residue definition in plant and animals is therefore:

1) For enforcement

The parent malathion defined as: diethyl mercapto-succinate S -(O,O -dimethyl phosphorodithioate)

2) For risk assessment and field trials

The parent malathion defined as: diethyl mercapto-succinate S -(O,O -dimethyl phosphorodithioate) and; The metabolite malaoxon defined as: 2-(dimethoxyphosphorylthio) butanedioic acid diethyl ester.

8.1.1.4 Maximum Residue Limits for Malathion in Food

In general, when the re-evaluation of a pesticide has been completed, the PMRA intends to update Canadian maximum residue limits (MRLs) and to remove MRLs that are no longer supported. The PMRA recognizes, however, that interested parties may want to retain an MRL in the absence of a Canadian registration to allow legal importation of treated commodities into Canada. The PMRA requires similar chemistry and toxicology data for such import MRLs as those required to support Canadian food use registrations. In addition, the PMRA requires residue data that are representative of use conditions in exporting countries, in the same manner that representative residue data are required to support domestic use of the pesticide. These requirements are necessary so that the PMRA may determine whether the requested MRLs are needed, and to ensure they would not result in unacceptable health risks.

Table 4 (Appendix VIII) lists all registered or supported commodities with existing MRL, tolerances and Codex MRL. Residues in all agricultural commodities, including those approved for treatment in Canada but without a specified MRL (such as grain crops, beef and milk), must not exceed 0.1 ppm, a general MRL specified in subsection B.15.002(1) of the FDR. Changes to this general MRL may be implemented in the future, as indicated in Discussion Document DIS2006-01 Revocation of 0.1 ppm as a General Maximum Residue Limit for Food Pesticide Residues [Regulation B.15.002(1)].

Raw cereals are defined (as per FAO/CODEX) as the seeds of barley, oats and rice in the husk and do have an MRL of 8 ppm in Canada, but edible residue are not defined. The PMRA proposes 0.1 ppm until revision of GMRL is completed.

Although residues on citrus imported from the US did not pose a concern, the default general MRL of 0.1 ppm has been violated during routine surveillance by the CFIA. Registrants are invited to petition for proper MRL values on citrus fruit to avoid potential trade issues on this important commodity.

Parties interested in supporting an import MRL for residues of malathion should contact the PMRA during the comment period of this document to discuss the submission of appropriate data.

8.1.2 Proposed Regulatory Action Related to Environment

The risk assessment of malathion indicates that adverse effects on pollinators, birds, aquatic invertebrates, fish and amphibians are anticipated. To reduce the effects of malathion in the environment, mitigation in the form of precautionary label statements and spray buffer zones are required. Environmental mitigation measures as label statements are listed in Appendix XXII.

8.2 Additional Data Requirements

The following studies or suitable scientific rationale will be required as a condition of continued registration under section 12 of the *Pest Control Product Act*:

8.2.1 Data Requirements Related to Chemistry

DACO: 2.13.3	Analytical data from five recent batches of the TGAI, manufactured at Thyboronvej 78, Harboore, Denmark, to 0.1% as per Section 2.13.3 of Dir98-04 including the impurities of toxicological concern present in the TGAI at any level.
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8.2.2 Data Requirements Related to Toxicology

DACO 4.8	Immunotoxicity study (Based on suggestive evidence in the public literature).
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8.2.3 Data Requirements Related to Occupational Exposure Assessment

- DACO 5.2 Use Description/Scenario (Application and Post-Application) - Information which fully describes the use of the product and human activity associated with its use in grape vines (nursery stock), livestock, stored grain, structural uses, and mushroom houses.
- DACO 5.6/5.7/5.9 Post-Application - Passive dosimetry or biological monitoring data and/or dislodgeable/transferable residues. Post-application exposure estimates for workers re-entering mushroom houses following application of malathion. Potential exposure to malaoxon should also be characterized.
- DACO 5.6/5.7/5.9 Post-Application - Passive dosimetry or biological monitoring data and/or dislodgeable/transferable residues. Post-application exposure estimates for workers re-entering structural sites (for example, flour mills) following application of malathion. Potential exposure to malaoxon should also be characterized.
- DACO 5.9 Dislodgeable/Transferable Residues - Residue studies that measure the formation and dissipation of malaoxon in airborne spray and, particularly, in deposited surfaces such as hard surfaces (such as decks and playstructures) and turf over a 10- to 30- day period following application of ULV malathion.

8.2.4 Data Requirements Related to Food Residue Chemistry

The following studies and data gaps are unique to the Canadian situation. They are required to validate assumptions made for stored grain applications and for the direct treatment on livestock:

- DACO 6.2 Metabolism studies arising from direct treatment on animal skin.
- DACO 7.6 Field trials on livestock to measure residues arising from direct treatment on animal skin.
- DACO 7.4 Magnitude of residue resulting from application to stored grains.

The following are existing studies already submitted to other agencies and/or task forces. They are required to validate assumptions made in dietary assessment:

- DACO 7.4 Magnitude of residue, decline, confined and field rotation, process and feed studies are required for the majority of crop groups in Use Site Categories 3, 5, 7, 8, 10, 12, 13, 14 and 20, as detailed in Appendix II.

8.2.5 Data Requirements Related to Environment

No additional data are required for continued registration of malathion, however, the PMRA is soliciting the following information which could be considered in refining the risk assessment:

- comments on the feasibility of the proposed buffer zones for aerial applications, and
- mesocosm studies to refine the aquatic risk assessment.

8.2.5 Data Requirements Related to Value

Most end use product labels do not include recommendations pertaining to droplet size and quantity of water in which applications are to be made, which could potentially impact product efficacy and coverage. The environmental assessment proposes a coarse droplet size which reduces buffer zones, however, the PMRA does not have data to demonstrate efficacy under such conditions of use. Thus, the following would be required to support continued registration:

- data or scientific rationale to show that a coarse droplet size when applied by air at a spray volume of 45 L/hectare is efficacious against the crop and pest combinations on the malathion labels; and
- data or scientific rationale to show that a coarse droplet size when applied by ground is efficacious. Also, the registrant is to provide spray volume recommendations for ground application to ensure sufficient water is applied to achieve thorough coverage and optimum insect control.

List of Abbreviations

♂	male
♀	female
λ	wavelength(s)
ADI	acceptable daily intake
a.i.	active ingredient
ARfD	acute reference dose
ARTF	agricultural Re-entry Task Force
ASAE	American Society of Agricultural Engineers
BMDL ₁₀	lower one-sided confidence limit on the benchmark dose
bw	body weight
CAS	Chemical Abstract Service
CFIA	Canadian Food Inspection Agency
ChE	acetylcholinesterase
cm	centimetre(s)
d	day(s)
DA	dermal absorption
DACO	data code
DRA	dietary risk assessment
DEEM-FCID	dietary exposure evaluation model – food consumption intake database
DNA	deoxyribonucleic acid
DNT	developmental neurotoxicity study
DFR	dislodgeable foliar residue
DT	dust
DT ₅₀	dissipation time to 50% (the dose required to observe a 50% decline in the test population)
EC	emulsifiable concentrate
EC50	exposure concentration to 50% (a concentration causing 50% adverse effects in the test population)
EChE	erythrocyte acetylcholinesterase
EDE	estimated daily exposure
EEC	expected environmental concentration
EPA	Environmental Protection Agency
g	gram(s)
ha	hectare
IPM	integrated pest management
IUPAC	International Union of Pure and Applied Chemistry
JMPR	joint FAO/WHO meeting on pesticide residues
kg	kilogram
Kow	n-octanol–water partition coefficient
L	litre(s)
LOAEL	lowest observed adverse effect level
LC ₅₀	lethal concentration to 50% (a concentration causing 50% mortality in the test population)
LD ₅₀	lethal dose to 50% (a dose causing 50% mortality in the test population)
LOC	level of concern

LOD	limit of detection
LPM	litres per minute
mg	milligram(s)
MRID	document identifier for the US EPA
MOA	mode of action
MOE	margin of exposure
MRL	maximum residue limit
MTD	maximum tolerated doses
N/A	not applicable
NOEC	no observed effect concentration
NOAEL	no observed adverse effect level
ORETF	Outdoor Residential Exposure Task Force Database
PCPA	<i>Pest Control Products Act</i>
pH	-log ₁₀ hydrogen ion concentration
PHED	pesticide handlers exposure database
PHI	pre-harvested interval
PMRA	Pest Management Regulatory Agency
PND	post-natal day
PPE	personal protective equipment
ppm	part per million
PRZM/EXAMS	pesticide root zone model/exposure analysing modeling system
PYO	pick your own facilities
REI	restricted entry interval
RQ	risk quotient
TC	transfer coefficient
TSMP	toxic substances management policy
mg	microgram(s)
μM	micromolar
URMULE	user requested minor use label expansion
UK MAFF	United Kingdom, Ministry of Agriculture, Fisheries, and Food
USA	United States of America
UV	ultraviolet/visible spectrum
US EPA	United States Environmental Protection Agency
WSP	water soluble packaging

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Appendix I Registered malathion products in Canada as of April 10, 2008.

Registration Number	Marketing Class ¹	Registrant	Product Name	Formulation Type ²	Guarantee ³
4590	C	CHEMINOVA CANADA INC.	FYFANON 50% EMULSIFIABLE CONCENTRATE INSECTICIDE	EC	MAL:500 g/L
4709	C	UNITED AGRI PRODUCTS CANADA INC.	MALATHION 500E INSECTICIDE	EC	MAL:500 g/L
5821	C	INTERPROVINCIAL COOPERATIVE LIMITED	MALATHION 500 EMULSIFIABLE CONCENTRATE INSECTICIDE	EC	MAL:500 g/L
8372	C	UNITED AGRI PRODUCTS CANADA INC.	MALATHION 85E	EC	MAL:85 %
8624	C	GARDEX CHEMICALS LTD.	GARDEX MALATHION 50% EC INSECTICIDE	EC	MAL:500 g/L
8826	C	GARDEX CHEMICALS LTD.	GARDEX LIQUID GRAIN PROTECTANT	EC	MAL:83.6 %
12073	C	AGRIUM ADVANCED TECHNOLOGIES RP INC.	WILSON MALATHION 836 LIQUID GRAIN PROTECTANT	SN	MAL:83.6 %
13883	C	VÉTOQUINOL N.-A. INC.	MALATHION 50 INSECTICIDE	EC	MAL:534 g/L
14265	C	AGRIUM ADVANCED TECHNOLOGIES RP INC.	WILSON MALATHION 3% RESIDUAL INSECTICIDE	SN	MAL:3 %
14656	C	UNITED AGRI PRODUCTS CANADA INC.	MALATHION 25W WETTABLE POWDER INSECTICIDE	WP	MAL:25 %
15896	C	UNITED AGRI PRODUCTS CANADA INC.	MALATHION GRAIN PROTECTOR DUST	DU	MAL:2 %
16099	C	AGRIUM ADVANCED TECHNOLOGIES RP INC.	WILSON MALATHION 50 E.C. LIQUID INSECTICIDE	EC	MAL:50 %
16198	C	GARDEX CHEMICALS LTD.	MALATHION ULV CONCENTRATE	EC	MAL:96.5 %
16706	C	AGRIUM ADVANCED TECHNOLOGIES RP INC.	WILSON MR II MUSHROOM FLY INSECTICIDE DUST	DU	PYR:0.10 % PBU:1.00 % MAL:4.00 %
17222	C	INTERPROVINCIAL COOPERATIVE LIMITED	IPCO MALATHION 2% GRAIN PROTECTANT DUST	DU	MAL:2 %
17463	C	AGRIUM ADVANCED TECHNOLOGIES RP INC.	WILSON MALATHION GRAIN PROTECTOR DUST	DU	MAL:2.0 %
17682	C	PLUS QUEBEC INC.	MALATHION - PLUS POWDER ANIMAL INSECTICIDE	DU	MAL: 4 %
18149	C	INTERPROVINCIAL COOPERATIVE LIMITED	CO-OP BACKRUBBER CONCENTRATE LIQUID INSECTICIDE	SN	MAL:500 g/L

Registration Number	Marketing Class ¹	Registrant	Product Name	Formulation Type ²	Guarantee ³
23421	C	AGRIUM ADVANCED TECHNOLOGIES RP INC.	WILSON VET TEK BACKRUBBER CONCENTRATE	SN	MAL:51.5 %
27095	C	LEWIS CATTLE OILER CO. LTD.	OAK LAKE CATTLE BACKRUBBER LIQUID CONCENTRATE	SN	MAL:500 g/l.
9337	C + R	CHEMINOVA CANADA INC.	FYFANON ULV ULTRA LOW VOLUME CONCENTRATE INSECTICIDE	SN	MAL:96.5 %
14597	C + R	AGRIUM ADVANCED TECHNOLOGIES RP INC.	WILSON MALATHION ULV INSECTICIDE CONCENTRATE	LI	MAL:96.5 %
25638	C + R	UNITED AGRI PRODUCTS CANADA INC.	MALATHION 95 ULV INSECTICIDE	EC	MAL:96.5 %
4282	D	SCOTT CANADA LTD.	GREEN CROSS MALATHION 500 EC LIQUID INSECTICIDE	EC	MAL: 500 g/l.
6713	D	SURE-GRO IP INC.	LATER'S MALATHION 50 INSECT SPRAY	EC	MAL: 50 %
8480	D	INTERPROVINCIAL COOPERATIVE LIMITED	CO-OP MALATHION LIQUID INSECTICIDE EC	EC	MAL:47 %
9802	D	SURE-GRO IP INC.	WILSON 50% MALATHION LIQUID INSECTICIDE-MITICIDE	EC	MAL:50 %
9986	D	KING HOME & GARDEN INC.	KING FRUIT TREE & GARDEN SPRAY	DU	MAL:5 % CAP:10 % CAB:10 %
10565	D	SURE-GRO IP INC.	WILSON ROSE DOCTOR INSECTICIDE-FUNGICIDE	DU	CAB:5 % MAL:4 % FOL:5 %
14851	D	KING HOME & GARDEN INC.	GARDAL ROSE, FLOWER, & EVERGREEN DUST	DU	TPM:3 % MAL:4 % CAP:5 % CAB:5 %
17816	D	SURE-GRO IP INC.	C-I-I. MALATHION ORNAMENTAL INSECT KILLER	EC	MAL:125 g/l.
21850	D	SURE-GRO IP INC.	WILSON HOSE-SPRAY MALATHION INSECTICIDE-MITICIDE	EC	MAL:15 %
18150	T	CHEMINOVA CANADA INC.	FYFANON TECHNICAL	LI	MAL:96.5 %

¹ C = Commercial Class; D = Domestic Class; T = Technical Class; R = Restricted Class

² Formulation type based on PMRA's Oracle database: DU = Dust or Powder; EC = Emulsifiable Concentrate or Emulsion; LI = Liquid; SN = Solution; and WP = Wettable Powder

³ CAB: carbaryl; CAP: captan; FOL: folpet; MAL: malathion; PBU: piperonyl butoxide; PYR: pyrethrins; TPM: thiophanate-methyl

Appendix IIa Registered Commercial and Restricted Class uses of malathion in Canada as of April 10, 2008

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ¹ (Max. # of applications/season supported by registrant) ²	Minimum interval between applications ^{3,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
USC 2 -Aquatic non-food sites								
Mosquito breeding areas	Mosquitoes (larvae)	EC, LI, SN	Aerial: ULV	652.82 g /ha (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
Standing water (self-contained)	Mosquitoes (larvae)	EC,SN	Ground, equipment type not specified	579.7 g in oil or water/ha (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	
USC 3 -Empty food storage areas								
Bins and elevators	confused flour beetle, flat grain beetle, granary weevil, grain mites, Indianmeal moth, lesser grain borer, red flour beetle, rice weevil, rusty grain beetle, sawtoothed grain beetle	EC	Crack, crevice and broadcast surface spray, equipment type not specified	167.2 g in 5 L water or deodorized kerosene/100 m ² surface area (Not specified)	Cannot calculate (Cannot calculate)	Not specified (Not specified)	[21] ⁵ (Not specified)	(Yes)
		EC, SN	Spray, pressure sprayer or paint brush (SN)	201 g in 5 L water/100 m ² surface area (Not specified)			[14] ⁵ (Not specified)	
Box cars	confused flour beetle, flat grain beetle, granary weevil, grain mites, Indianmeal moth, lesser grain borer, red flour beetle, rice weevil, rusty grain beetle, sawtoothed grain beetle	EC, SN	Crack, crevice and broadcast surface spray, equipment type not specified (EC)	167 g in 5 L of water or deodorized kerosene /100 m ² surface area (Not specified)	167 g in 5 L of water or deodorized kerosene /100 m ² surface area (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)
			Spray, pressure spray or paint brush (SN)	122 g in 5 L water /100 m ² surface area (Not specified)	122 g in 5 L water /100 m ² surface area (Cannot calculate)			
Flour mill warehouses	confused flour beetle, flat grain beetle, granary weevil, grain mites, Indianmeal moth, lesser grain borer, red flour beetle, rice weevil, rusty grain beetle, sawtoothed grain beetle	EC, SN	Crack, crevice and broadcast surface spray, equipment type not specified (EC)	167.2 g in 5 L water or deodorized kerosene /100 m ² surface area (Not specified)	Cannot calculate (Cannot calculate)	Not specified (Not specified)	Not specified (Not specified)	(Yes)
			Spray, pressure spray or paint brush (SN)	122 g in 5 L water /100 m ² surface area (Not specified)				
USC 5 -Greenhouse food crops								
Lettuce	aphids, spider mites	EC, WP	Spray, equipment type not specified	1376.5 g/ha (1375 g/ha)	2753 g/ha (1375 g/ha)	2 (1)	Not specified (Not applicable)	(Yes)
	armyworms, greenhouse whitefly, thrips	EC						
	Mexican bean beetle	WP		1375 g/ha (1375 g/ha)	2750 g/ha (1375 g/ha)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant					
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³								
Mushroom beds	phorid flies, sciarid flies	EC	Spray, equipment type not specified	21.08 g in 11 L / 100 m ² of bed (20 g/100 m ² of bed)	[63.2 g/100 m ² of bed] ⁸ (60 g/100 m ² of bed)	Not specified (3)	Not specified (3)	(Yes, M)					
			Spray mist, equipment type not specified	18.7 g in 100 L / 100 m ² of bed (20 g/100 m ² of bed)	[56.1 g/100 m ² of bed] ⁸ (60 g/100 m ² of bed)								
		WP	Spray, equipment type not specified	18 g/100 m ² (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)					
		DJ	Dust, Dusting Machine	15 g/100 m ² (Not applicable)									
	mites	EC	Spray, equipment type not specified	21.08 g in 11 L / 100 m ² (20 g/100 m ² of bed)	[63.2 g/100 m ²] ⁸ (60 g/100 m ² of bed)	Not specified (3)	Not specified (3)	(Yes)					
		WP		18 g/100 m ² (Not applicable)	Not specified (Not applicable)				Not specified (Not applicable)	(No)			
Mushroom houses	mites	EC	Spray or as a paint, equipment type not specified	20.5 g in 11 L / 100 m ² (20.0 g/100 m ²)	[61.5 g/100m ²] ⁸ (60 g/100 m ² of bed)	Not specified (3)	Not specified (3)	(Partial but not application method applied as a paint)					
	phorid flies, sciarid flies	EC, WP						(Partial but not application method applied as a paint, M)					
								(Partial, EC formulation supported, WP formulation not supported)					
		Dust	Dust, dusting machine	15 g/100 m ² (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)					
USC 6 -Greenhouse ornamental crops													
Carnation, chrysanthemum, geranium, rose, snap dragon	aphids, mealybugs, spider mites, thrips, whiteflies	EC	Spray, equipment type not specified	8.0 g/100 m ² (9.76 g/100 m ²)	[32.0 g/100 m ²] ⁸ (39.04 g/100 m ²)	Not specified (4)	[10] ⁹ (Not specified)	(Yes)					
			Fogging, equipment type not specified	5 g/100 m ² (Not applicable)	15 g/100 m ² (Not applicable)	3 (Not applicable)	4 (Not applicable)	(No)					
	greenhouse whitefly		Spray, equipment type not specified	7.5 g/100 m ² (9.76 g/100 m ²)	[30.0 g/100 m ²] ⁸ (39.04 g/100 m ²)	Not specified (4)	[10] ⁹ (Not specified)	(Yes)					
			Fogging, equipment type not specified	5 g/100 m ² (Not applicable)	15 g/100 m ² (Not applicable)	3 (Not applicable)	4 (Not applicable)	(No)					
Ornamental plants	aphids, mealybugs, spider mites, thrips	EC, WP	Spray, equipment type not specified	[11.23 g/100 m ²] ¹⁰ (9.76 g/100 m ²)	[44.92 g/100 m ²] ⁸ (39.04 g/100 m ²)	Not specified (4)	[10] ⁹ (Not specified)	(Partial EC formulation supported, WP formulation not supported)					
	greenhouse whitefly	WP		7.5 g/100 m ² (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)		(No)					
	leafhoppers whiteflies	EC		[11.23 g/100 m ²] ¹⁰ (9.76 g/100 m ²)	[44.92 g/100 m ²] ⁸ (39.04 g/100 m ²)	Not specified (4)		(Yes)					

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
USC 7 -Industrial oilseed crops and fibre crops								
Canola (Rapeseed)	diamondback moth (adult)	EC	Aerial, Low volume aircraft	454 g/ha (Not specified)	[454 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	diamondback moth (larvae)		Ground, equipment type not specified	527 g/ha (Not specified)	[527 g/ha] ⁸ (Cannot calculate)			
	flea beetles	EC, SN, LI	Ground ULV	504.45 g/ha (Not specified)	[504.45 g/ha] ⁸ (Cannot calculate)			
		EC	Aerial	425 g/ha (Not specified)	[425 g/ha] ⁸ (Cannot calculate)			
			Ground, equipment type not specified	850 g/ha (Not specified)	[850 g/ha] ⁸ (Cannot calculate)			
		Aerial		875 g/ha (Not specified)	[875 g/ha] ⁸ (Cannot calculate)			
			grasshoppers	Ground, equipment type not specified	935 g/ha (Not specified)			
		Aerial		875 g/ha (Not specified)	[875 g/ha] ⁸ (Cannot calculate)			
Flax	grasshoppers	EC	Ground, equipment type not specified	935 g/ha (875 g/ha)	[935 g/ha] ⁸ (875 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
			Aerial	875 g/ha (875 g/ha)	[875 g/ha] ⁸ (875 g/ha)			
Mustard	diamondback moth	EC	Aerial	454 g/ha (Not specified)	[454 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	diamond back larvae		Ground, equipment type not specified					
			Aerial	425 g/ha (Not specified)	[425 g/ha] ⁸ (Cannot calculate)			
	flea beetles, grasshoppers	Ground, equipment type not specified	875 g/ha (Not specified)	[875 g/ha] ⁸ (Cannot calculate)				
		Aerial						

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant	
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³				
USC 8 - Livestock for Food									
Beef and dairy cattle (non-lactating)	black flies, face fly stable fly	SN	Backrubber	20 g/L diesel or No. 2 fuel oil (Not specified)	Cannot calculate (Cannot calculate)	Not applicable	Continuously available	(Yes)	
	flies			20.5 g/L diesel or fuel oil (Not specified)					
	gnats	EC	Spray, equipment type not specified	5 g/L water (Not specified)	Cannot calculate (Cannot calculate)	Not specified (2)	Not specified (Not specified)		
	horn fly	EC, SN	Backrubber	21.08 g/L diesel or No. 2 fuel oil (Not specified)		Not applicable	Continuously available		
				20 g/L fuel oil (Not specified)					
			Spray (EC), equipment type not specified	5.27 g/L water (Not specified)		Not specified (2)	Not specified (Not specified)		
		DU	Dust, dust applicator	2.4 g/head (Not specified)	2.4 g/head (Cannot calculate)	1 (2)	Not applicable (Not specified)		
	lice	EC, SN	Backrubber	21.08 g/L diesel or fuel oil (Not specified)	Cannot calculate (Cannot calculate)	Not applicable	Continuously available		
				20 g/L fuel oil (Not specified)					
			Spray (EC), equipment type not specified	21.36 g/L water (Not specified)		Not specified (2)	Not specified (Not specified)		
				20.8 g/L fuel or diesel oil (Not specified)					
		DU	Dust, dust applicator	2.4 g/head (Not specified)	4.8 g/head (Cannot calculate)	2	10		
	mosquitoes	EC, SN	Backrubber	20 g/L diesel or No. 2 fuel oil (Not specified)	Cannot calculate (Cannot calculate)	Not applicable	Continuously available		
			Spray (EC), equipment type not specified	5 g/L water (Not specified)		Not specified (2)	Not specified (Not specified)		
		ticks	EC			10.54 g/L (Not specified)			
Dairy cattle (lactating)	black flies, face fly, stable fly mosquitoes	SN	Backrubber	20 g/L diesel or No. 2 fuel oil (Not specified)	Cannot calculate (Cannot calculate)	Not applicable	Continuously available	(Yes)	
	flies			20.5 g/L diesel or fuel oil (Not specified)					
	horn fly	EC, SN	Backrubber	21.08 g/L diesel or fuel oil (Not specified)	Cannot calculate (Cannot calculate)	Not applicable	Continuously available	(Yes)	
				DU					Dust, dust applicator

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁷	Minimum interval between applications ^{6,7} (days)	Use Supported by Registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
	lice	EC, SN	Backrubber	21.08 g/l. diesel or fuel oil (Not specified)	Cannot calculate (Cannot calculate)	Not applicable	Continuously available	
		DU	Dust, dust applicator	2.4 g/head (Not specified)	4.8 g/head (Cannot calculate)	2 (Not specified)	10 Treat lactating dairy cattle only after milking (Not specified)	
Goats	horn fly, lice	EC	Spray, equipment type not specified	5.27 g/L (Not specified)	Cannot calculate (Cannot calculate)	Not specified (2)	Not specified (Not specified)	(Yes)
	ticks			10.54 g/L (Not specified)				
Goats (non-milking)	ked, lice, ticks	EC	Spray, equipment type not specified	5 g/ l. water (Not specified)	Cannot calculate (Cannot calculate)	2 (2)	14 (Not specified)	(Yes)
Poultry	lice, Northern fowl mite, red mite (aid to control)	EC	Spray, equipment type not specified	0.31 g/bird (Not specified)	[0.61 g/bird] ⁸ (Cannot calculate)	Not specified (2)	30 (Not specified)	(Yes)
Sheep	horn fly, lice	EC	Spray, equipment type not specified	5.27 g/L (Not specified)	Cannot calculate (Cannot calculate)	Not specified (2)	[14] ⁹ (Not specified)	(Yes)
	mosquitoes, ked			5.0 g/L (Not specified)				
	ticks			10.54 g/L (Not specified)				
Swine	horn fly	EC	Spray, equipment type not specified	5.27 g/L (Not specified)	Cannot calculate (Cannot calculate)	Not specified (2)	[12] ¹⁰ (Not specified)	(Yes)
	lice							
		DU	Dust, dust applicator	1.2 g/head (Not specified)	2.4 g/head (Cannot calculate)	2 (2)	14 (Not specified)	
	sarcoptic mange mite	EC	Spray, equipment type not specified	23 g/hog (Not specified)	[46 g/hog] ¹¹ (Cannot calculate)	Not specified (2)	12 (Not specified)	
ticks	10.54 g/L (Not specified)			Cannot calculate (Cannot calculate)	[12] ¹¹ (Not specified)			
USC 10-Seed treatments food and feed and Seed Treatment Non-Food USC 11								
Seeds (field and garden)	confused flour beetle, flat grain beetle, granary weevil, Indianmeal moth, lesser grain borer, rusty grain beetle, saw toothed grain beetle	DU	Dust, equipment not specified	1.2 g/100 kg of seed (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
USC 12 -Stored food and feed								
Grains	flour beetles, granary weevil, rice weevil	EC	Surface spray, most effective if raked into the surface to a depth of 8 to 10 cm	162.5 g/5 L water/ 100 m ² grain surface (Not specified)	162.5 g/5 L water/ 100 m ² grain surface (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Barley	grain mites	EC	Surface spray, equipment type not specified	12.28 g in 10 - 20 L water/1000 kg of grain (Not specified)	12.28 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)
	red flour beetle			13.04 g in 10 - 20 L water/1000 kg of grain (Not specified)	13.04 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)			
	lesser grain borer, rusty grain beetle			13.04 g in 10 - 20 L water/1000 kg of grain (Not specified)	13.04 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)			
	Indianmeal moth	DU	Top dressing (broadcast), cut the dust into the grain with a shovel	10.4 g/1000 kg of grain (Not specified)	10.4 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
		SN	Surface spray, equipment not specified	30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			
				301.5 g in 5 - 10 L water/100m ² of grain surface (Not specified)	301.5 g in 5 - 10 L water/100m ² of grain surface (Cannot calculate)			
		EC	Surface spray and rake to a depth of 15 cm, any standard spray applicator. For small amounts of grain, any type of low pressure sprayer holding 4L or more. Spray applied to grain stream as grain being elevated into storage.	301.9 g/5-10 L water per 100 m ² of grain (Not specified)	301.9 g/5-10 L water per 100 m ² of grain (Cannot calculate)			
				301 g in 5 - 10 L water/100m ² of grain surface (Not specified)	301 g in 5 - 10 L water/100m ² of grain surface (Cannot calculate)			
				301 g in 5 - 10 L water/100m ² of grain surface (Not specified)	301 g in 5 - 10 L water/100m ² of grain surface (Cannot calculate)			
		DU	Top dressing (broadcast), cut the dust into the grain with a shovel	10.4 g/1000 kg of grain (Not specified)	10.4 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
	merchant grain beetle	DU	Top dressing (broadcast), cut the dust into the grain with a rake to a depth of 15 cm	10.4 g/1000 kg of grain (Not specified)	10.4 g/1000 kg of grain (Cannot calculate)			
				90 g/100 m ² of grain surface (Not specified)	90 g/100 m ² of grain surface (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (day s)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ⁵	Maximum Cumulative ² (calculated rate based on registrant information) ³			
	rice weevil	SN	Surface spray; equipment type not specified	30.15 g/1000 kg of grain	30.15 g/1000 kg of grain			
	confused flour beetle, flat grain beetle, granary weevil, sawtoothed grain beetle	EC		13.04 g in 10 - 20 L water/1000 kg of grain (Not specified)	13.04 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)			
		SN		30.15 g/1000 kg of grain	30.15 g/1000 kg of grain			
		DU	Top dressing (broadcast); cut the dust into the grain with a shovel	10.4 g/1000 kg of grain (Not specified)	10.4 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast); work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
Corn	grain mites	EC	Surface spray; equipment type not specified	10.23 g/1000 kg of grain (Not specified)	10.23 g/1000 kg of grain (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)
	lesser grain borer, red flour beetle, rusty grain beetle			11.04 g/1000 kg of grain (Not specified)	11.04 g/1000 kg of grain (Cannot calculate)			
	Indianmeal moth	SN	Surface spray and rake to a depth of 15 cm; any standard spray applicator. For small amounts of grain, any type of low pressure sprayer holding 4L or more.	301.9 g/100 m ² of grain surface (Not specified)	301.9 g/100 m ² of grain surface (Cannot calculate)			
				30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			
		EC		301.5 g in 5 -10 L water/100m ² of grain surface (Not specified)	301.5 g in 5 -10 L water/100m ² of grain surface (Cannot calculate)			
	confused flour beetle, flat grain beetle, granary weevil, rice weevil, sawtoothed grain beetle	SN	Surface spray; equipment type not specified	30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Not specified)			
		EC		11.04 g/1000 kg of grain (Not specified)	11.04 g/1000 kg of grain (Not specified)			
					30.15 g/1000 kg of grain (Not specified)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ¹ (Max. # of applications/season supported by registrant) ²	Minimum interval between applications ^{4,5} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ³	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Oats	gram mites	EC	Surface spray, equipment type not specified	17.4 g in 10 - 20 L water/1000 kg of grain (Not specified)	17.4 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)
	rod flour beetle			18.06 g in 10 - 20 L water/1000 kg of grain (Not specified)	18.06 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)			
	lesser grain borer, rusty grain beetle							
		DJ	Top dressing (broadcast), cut the dust into the grain with a shovel	14.7 g/1000 kg of grain (Not specified)	14.7 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
	Indianmeal moth	SN	Surface spray, equipment type not specified	30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			
				301.5 g in 5 - 10 L water /100 m ² of grain (Not specified)	301.5 g in 5 - 10 L water /100 m ² of grain (Cannot calculate)			
		EC		301 g in 5 - 10 L water /100 m ² of grain (Not specified)	301 g in 5 - 10 L water /100 m ² of grain (Cannot calculate)			
			Surface spray and rake to a depth of 15 cm, any standard spray applicator. For small amounts of grain, any type of low pressure sprayer holding 4L, or more. Spray applied to grain stream as grain being elevated into storage	301.9 g in 5 - 10 L water /100 m ² of grain (Not specified)	301.9 g in 5 - 10 L water / 100 m ² of grain (Cannot calculate)			
		DR	Top dressing (broadcast), cut the dust into the grain with a shovel	14.7 g/1000 kg of grain (Not specified)	14.7 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
	merchant grain beetle	DJ	Top dressing (broadcast), equipment type not specified	14.7g/1000 kg of grain (Not specified)	14.7g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	90 g/100 m ² of grain surface (Not specified)	90 g/100 m ² of grain surface (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
	rice weevil	SN	Surface spray, equipment type not specified	30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			
	confused flour beetle, flat grain beetle, granary weevil, sawtoothed grain beetle	EC		18.06 g in 10 - 20 L water/1000 kg of grain (Not specified)	18.06 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)			
		SN		30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			
		DL	Top dressing (broadcast), cut the dust into the grain with a shovel	14.7 g/1000 kg of grain (Not specified)	14.7 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
Rice	confused flour beetle, flat grain beetle, granary weevil, Indian meal moth, lesser grain borer, rusty grain beetle, sawtoothed grain beetle	DL	Top dressing (broadcast), cut the dust into the grain with a shovel	11 g/1000 kg of grain (Not specified)	11 g/1000 kg of grain (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
			Top dressing (broadcast), equipment type not specified	11 g/1000 kg of grain (Not specified)	11 g/1000 kg of grain (Cannot calculate)			
	merchant grain beetle		Top dressing (broadcast), work into a depth of 15 cm with a rake	90 g/100 m ² of grain surface (Not specified)	90 g/100 m ² of grain surface (Cannot calculate)			
Rye	grain mites	EC	Surface spray, equipment type not specified	10.23 g in 10 - 20 L water/1000 kg of grain (Not specified)	10.23 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)
	red flour beetle			11.04 g in 10 - 20 L water/1000 kg of grain (Not specified)	11.04 g in 10 - 20 L water/1000 kg of grain (Cannot calculate)			
	lesser grain borers, rusty grain beetle							
		DL	Top dressing (broadcast), cut the dust into the grain with a shovel	9 g/1000 kg of grain (Not specified)	9 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
	Indian meal moth	SN	Surface spray, equipment type not specified	30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
		EC		301.5 g in 5 - 10 L water/100 m ² of grain surface (Not specified)	301.5 g in 5 - 10 L water/100 m ² of grain surface (Cannot calculate)			
				301 g in 5 - 10 L water /100 m ² of grain (Not specified)	301 g in 5 - 10 L water /100 m ² of grain (Cannot calculate)			
			Surface spray and rake to a depth of 15 cm, any standard spray applicator. For small amounts of grain, any type of low pressure sprayer holding 4 L or more. Spray applied to grain stream as grain being elevated into storage	301.9 g/100 m ² of grain surface (Not specified)	301.9 g/100 m ² of grain surface (Cannot calculate)			
		DL	Top dressing (broadcast), cut the dust into the grain with a shovel	9 g/1000 kg of grain (Not specified)	9 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
		DL	Top dressing (broadcast), equipment type not specified	9 g/1000 kg of grain (Not specified)	9 g/1000 kg of grain (Cannot calculate)			
	merchant grain beetle		Top dressing (broadcast), work into a depth of 15 cm with a rake	90 g/100 m ² of grain surface (Not specified)	90 g/100 m ² of grain surface (Cannot calculate)			
	rice weevil	SN	Surface spray, equipment type not specified	30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			
	confused flour beetle, flat grain beetle, granary weevil, sawtoothed grain beetle	EC		11.04 g in 10 - 20 L water/1000 kg of grain (Not specified)	11.04 g in 10 - 20 L water/1000 kg of grain (Not specified)			
		SN		30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Not specified)			
		DL	Top dressing (broadcast), cut the dust into the grain with a shovel	9 g/1000 kg of grain (Not specified)	9 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Wheat	rain mites	EC	Surface spray, equipment type not specified	10.23 g/1000 kg of grain (Not specified)	10.23 g/1000 kg of grain (Cannot calculate)	1 (Not specified)	Not applicable (Not specified)	(Yes)
	red flour beetle			10.03 g/1000 kg of grain (Not specified)	10.03 g/1000 kg of grain (Cannot calculate)			
	lesser grain borer, rusty grain beetle			10.23 g/1000 kg of grain (Not specified)	10.23 g/1000 kg of grain (Cannot calculate)			
	Indianmeal moth	DU	Top dressing (broadcast), cut the dust into the grain with a shovel	8.3 g/1000 kg of grain (Not specified)	8.3 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
		SN	Surface spray, equipment type not specified	30.15 g/1000 kg of grain (Not specified)	30.15 g/1000 kg of grain (Cannot calculate)			
				301.5 g in 5 - 10 L/100 m ² of grain surface (Not specified)	301.5 g in 5 - 10 L/100 m ² of grain surface (Cannot calculate)			
				301 g in 5 - 10 L water /100 m ² of grain (Not specified)	301 g in 5 - 10 L water /100 m ² of grain (Cannot calculate)			
		EC	Surface spray and rake to a depth of 15 cm, any standard spray applicator. For small amounts of grain, any type of low pressure sprayer holding 4 L or more	301.9 g/100 m ² of grain (Not specified)	301.9 g/100 m ² of grain (Cannot calculate)			
		DU	Top dressing (broadcast), cut the dust into the grain with a shovel	8.3 g/1000 kg of grain (Not specified)	8.3 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	95 g/100 m ² of grain surface (Not specified)	95 g/100 m ² of grain surface (Cannot calculate)			
	merchant grain beetle		Top dressing (broadcast), equipment type not specified	8.3 g/1000 kg of grain (Not specified)	8.3 g/1000 kg of grain (Cannot calculate)			
			Top dressing (broadcast), work into a depth of 15 cm with a rake	90 g/100 m ² of grain surface (Not specified)	90 g/100 m ² of grain surface (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ⁷ (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
	rice weevil	SN	Surface spray, equipment type not specified	30.15 g/1000 kg of grain <i>Not specified</i>	30.15 g/1000 kg of grain <i>(Cannot calculate)</i>			
	confused flour beetle, flat grain beetle granary weevil, sawtoothed grain beetle	EC		10.23 g/1000 kg of grain <i>(Not specified)</i>	10.23 g/1000 kg of grain <i>(Not specified)</i>			
		SN		30.15 g/1000 kg of grain <i>Not specified</i>	30.15 g/1000 kg of grain <i>Not specified</i>			
		DU	Top dressing (broadcast), cut the dust into the grain with a shovel	8.3 g/1000 kg of grain <i>(Not specified)</i>	8.3 g/1000 kg of grain <i>(Cannot calculate)</i>			
	Top dressing (broadcast), work into a depth of 15 cm with a rake		95 g/100 m ² of grain <i>(Not specified)</i>	95 g/100 m ² of grain <i>(Cannot calculate)</i>				
USC 13 -Terrestrial food crops								
Alfalfa	alfalfa blotch leafminer spider mites spittlebugs (adults)	EC	Ground, equipment type not specified. Ground ULV Aerial	1376.5 g/ha <i>(1375 g/ha)</i>	[2753 g/ha] ⁸ <i>(2750 g/ha)</i>	Not specified <i>(2)</i>	Not specified <i>(14)</i>	<i>(Partial Ground ULV not supported)</i>
	alfalfa weevil, aphids, grasshoppers, leafhoppers, Lygus bug, spittle bugs		Ground, equipment type not specified. Aerial	1500 g/ha <i>(1375 g/ha)</i>	[3000 g/ha] ⁸ <i>(2750 g/ha)</i>			
	potato leafhopper	Ground, equipment type not specified.	1317.5 g/ha <i>(1375 g/ha)</i>	5270 g/ha <i>(2750 g/ha)</i>	4 <i>(2)</i>			
	young grasshoppers							
	alfalfa weevil (larvae)	Ground, equipment type not specified. Ground ULV Aerial	1376.5 g/ha <i>(1375 g/ha)</i>	5506 g/ha <i>(2750 g/ha)</i>				
			LI, SN	1305.65 <i>(1375 g/ha)</i>		5222.6 g/ha <i>(2750 g/ha)</i>		
Canary grass (for seed)	aphids	EC	Ground, equipment type not specified. Aerial	701 g/ha <i>(700 g/ha)</i>	[701 g/ha] ⁸ <i>(700 g/ha)</i>	Not specified <i>(1)</i>	Not specified <i>(Not applicable)</i>	<i>(Yes, M)</i>
Cereal crops (barley, oats, wheat), grasses or legumes grown for hay	armyworms	LI, SN	Ground ULV	652.82 g/ha <i>(Not specified)</i>	[652.82 g/ha] ⁸ <i>(Cannot calculate)</i>	Not specified <i>(1)</i>	Not specified <i>(Not applicable)</i>	<i>(Yes)</i>
	cereal leaf beetle	EC, LI, SN	Ground, equipment type not specified. Ground ULV Aerial					
	grasshoppers	EC	Ground, equipment type not specified. Aerial	850.0 g/ha <i>(Not specified)</i>	[850.0 g/ha] ⁸ <i>(Cannot calculate)</i>			
Clover	alfalfa weevil (larvae) young grasshoppers potato leafhopper	EC	Ground, equipment type not specified.	1317.5 g/ha <i>(1375 g/ha)</i>	[1317.5 g/ha] ⁸ <i>(1375 g/ha)</i>	Not specified <i>(1)</i>	Not specified <i>(Not applicable)</i>	<i>(Yes)</i>
	aphids grasshoppers leafhoppers spider mites spittle bugs			1376.5 g/ha <i>(1375 g/ha)</i>	[1376.5 g/ha] ⁸ <i>(1375 g/ha)</i>			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ²			
	green cloverworm	LI	Ground ULV	652.82 g/ha (1375 g/ha)	[652.82 g/ha] ⁸ (1375 g/ha)			
	greenworms	EC, SN						
Corn (forage and grain)	corn earworm, European corn borer	EC ⁹	Ground, equipment type not specified.	1376.5 g/ha (1375 g/ha)	6882.5 g/ha (5500 g/ha)	5 (4)	3 (Not specified)	(Yes)
	cereal leaf beetle		Ground ULV	652.82 g/ha (1375 g/ha)	[2611.28 g/ha] ⁸ (5500 g/ha)	Not specified (4)	2 (Not specified)	
Feedlot and stabling areas and pastures	adult mosquitoes, house flies, stable fly	EC, LI, SN	Ground ULV, Aerial ULV	652.82 g/ha (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
Non-agricultural land (wild host plants)	leafhoppers	EC, LI	Ground, ULV equipment, mist blowers and boom sprayers utilizing a controlled air flow to facilitate particle size and spray deposition	652.82 g/ha (Not specified)	Cannot calculate (Cannot calculate)	Not specified (Not specified)	Not specified (Not specified)	(Yes)
Pasture	young grasshoppers	EC ⁹	Ground	934.5 g/ha (1375 g/ha)	[934.5 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
Pastures and range (grass)	grasshoppers	EC, SN, LI	Ground, ULV equipment, mist blowers and boom sprayers utilizing a controlled air flow to facilitate particle size and spray deposition	1008.91 g/ha (1375 g/ha)	[1008.91 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	young grasshoppers		Ground, equipment type not specified.	1500 g/ha (1375 g/ha)	[1500 g/ha] ⁸ (1375 g/ha)			
Pasture and range (alfalfa)	young grasshoppers	EC ⁹	Ground, equipment type not specified.	1500 g/ha (1375 g/ha)	[1500 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
Sweet clover (field margins of first year clover)	sweet clover weevil	EC ⁹	Ground, equipment type not specified. Aerial	1250 g/ha (1250 g/ha)	1250 g/ha (1250 g/ha)	1 (1)	Not applicable (Not applicable)	(Yes)

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
USC 14 - Terrestrial food crops								
Apple	eyespot bud moth, mites, psyllids	EC	Ground, equipment type not specified	[3750 g/ha] ¹¹ (Not specified)	[7500 g/ha] ¹² (Cannot calculate)	Not specified (2)	[10] ⁸ (7)	(Yes)
	aphids, tent caterpillars	EC, WP						
	scale crawlers	EC		[3745.5 g/ha] ¹¹ (Not specified)	[7491 g/ha] ¹² (Cannot calculate)			
	bud moths, green apple aphid, rosy apple aphid, wooly apple aphid			[3952.5 g/ha] ¹¹ (Not specified)	[7905 g/ha] ¹² (Cannot calculate)			
	clover mite, codling moth, European red mite, mealybugs, plum curculio, redbanded leafroller, two spotted spider mite, yellow mite	EC, WP						
Apple (crab)	aphids, codling moth, eyespot bud moth, mealybugs, mites, plum curculio, psyllids, redbanded leafroller, tent caterpillars	EC	Ground, equipment type not specified	[3750 g/ha] ¹¹ (Not specified)	[7500 g/ha] ¹² (Cannot calculate)	Not specified (2)	[10] ⁸ (Not specified)	(Yes)
	bud moths, green apple aphid, rosy apple aphid			[2701.8 g/ha] ¹¹ (Not specified)	[5403.6 g/ha] ¹² (Cannot calculate)			
	clover mite, European red mite, scale crawlers, two spotted spider mite, yellow mite			[3745.5 g/ha] ¹¹ (Not specified)	[7491 g/ha] ¹² (Cannot calculate)			
	wooly apple aphid			[1875 g/ha] ¹¹ (Not specified)	[3750 g/ha] ¹² (Cannot calculate)			
Apricot	aphids, European fruit loquat scale, soft brown scale	EC	Ground, equipment type not specified	[3952.5 g/ha] ¹¹ (Not specified)	[3952.5 g/ha] ¹² (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	codling moth, orange tortrix, scale insects			[3750.0 g/ha] ¹¹ (Not specified)	[3750.0 g/ha] ¹² (Cannot calculate)			
Asparagus	asparagus beetle	EC, WP	Ground, equipment type not specified	1500 g/ha (1375 g/ha)	[1500 g/ha] (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Barley	armyworms	EC	Ground, equipment type not specified. Ground ULV Aerial (Low volume), fixed wing or rotary aircraft equipment	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	grasshoppers, winter grain mites, English grain aphid		Ground, equipment type not specified. Aerial (low volume), fixed wing or rotary aircraft equipment					
	cereal leaf beetle		1100.2 g/ha (1375 g/ha)	[1100.2 g/ha] ⁹ (1375 g/ha)				
	greenbug, gram aphids		1468.5 g/ha (1375 g/ha)	[1468.5 g/ha] ⁹ (1375 g/ha)				
	aphids		Ground, equipment type not specified	1317.5 g/ha (1375 g/ha)	[1317.5 g/ha] ⁹ (1375 g/ha)			
Bean	aphids, Mexican bean beetle	EC, WP	Ground, equipment type not specified	1500 g/ha (1375 g/ha)	[1500 g/ha] ⁹ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	spider mites			1468.5 g/ha (1375 g/ha)	[1468.5 g/ha] ⁹ (1375 g/ha)			
	flea beetles, mites, leafhoppers	EC		1500 g/ha (1375 g/ha)	[1500 g/ha] ⁹ (1375 g/ha)			
Beet (table)	aphids	EC, WP	Ground, equipment type not specified	1500 g/ha (1375 g/ha)	[1500 g/ha] ¹⁰ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cabbage looper, imported cabbageworm, pepper weevil (maggot)	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ¹⁰ (1375 g/ha)			
	flea beetles, leafhoppers, Mexican bean beetle, mites	EC		1500 g/ha (1375 g/ha)	[1500 g/ha] ⁹ (1375 g/ha)			
	leafminers spider mites			1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ⁹ (1375 g/ha)			
Blackberry	aphids, leafhoppers, rose chafer, spider mites thrips	EC	Ground, equipment type not specified	[2000 g/ha] ¹¹ (Not specified)	[4000 g/ha] ^{11,9} (Cannot calculate)	Not specified (2)	Not specified (7)	(Yes)

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Blueberry	aphids, cranberry fruitworm, spider mites, thrips	EC, WP	Ground, equipment type not specified	1023.4 g/ha (Not specified)	3070.2 g/ha (Cannot calculate)	3 (Not specified)	4 (Not specified)	(Yes)
	cherry fruitworm			562.9 g/ha (Not specified)	[1688.7 g/ha] ⁸ (Cannot calculate)	[3] ¹⁰ (Not specified)	[4] ⁸ (Not specified)	
	blueberry maggot (adults)	EC		562.5 g/ha (Not specified)	[1687.5 g/ha] ⁸ (Cannot calculate)			
	blueberry maggot	WP				3 (Not specified)	4 (Not specified)	
	leafhoppers, leafrollers, rose chafar, strawberry root weevil (BC only)	EC		1023.4 g/ha (Not specified)	3070.2 g/ha (Cannot calculate)			
Boysenberry	aphids, leafhoppers, rose chafar, spider mites, thrips	EC	Ground, equipment type not specified	[2000 g/ha] ¹² (Not specified)	[4000 g/ha] ^{12,13} (Cannot calculate)	Not specified (2)	Not specified (7)	(Yes)
Broccoli	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1500 g/ha (Not specified)	[1500 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetles, flea beetles, leafhoppers, spider mites	EC						
	pepper weevil (maggots)	WP		1375 g/ha (Not specified)	[1375 g/ha] ⁸ (Cannot calculate)			
Brussels sprouts	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1500 g/ha (Not specified)	[1500 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetles, flea beetles, leafhoppers, spider mites	EC						
	pepper weevil (maggot)	WP		1375 g/ha (Not specified)	[1375 g/ha] ⁸ (Cannot calculate)			
Cabbage	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1500 g/ha (Not specified)	[1500 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetles, flea beetles, leafhoppers, spider mites	EC						
	pepper weevil (maggot)	WP	Ground, equipment type not specified	1375 g/ha (Not specified)	[1375 g/ha] ⁸ (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ⁵	Maximum Cumulative ² (calculated rate based on registrant information) ⁵			
Canola (Rape)	diamondback moth	EC	Aerial, low volume aircraft	454 g/ha (Not specified)	[454 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	diamondback moth (larvae)		Ground, equipment type not specified	527 g/ha (Not specified)	[527 g/ha] ⁸ (Cannot calculate)			
	EC, LI, SN	Ground ULV	504.45 g/ha (Not specified)	[504.45 g/ha] ⁸ (Cannot calculate)				
	flea beetles	EC	Aerial, fixed wing or rotary aircraft	425 g/ha (Not specified)	[425 g/ha] ⁸ (Cannot calculate)			
			Ground, equipment type not specified	875 g/ha (Not specified)	[875 g/ha] ⁸ (Cannot calculate)			
		Aerial						
	grasshoppers	Ground, equipment type not specified	935 g/ha (Not specified)	[935 g/ha] ⁸ (Cannot calculate)				
		Aerial	850 g/ha (Not specified)	[850 g/ha] ⁸ (Cannot calculate)				
Carrot	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment not specified	1500 g/ha (Not specified)	[1500 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetles, flea beetles, leafhoppers, spider mites	EC						
	pepper weevil (maggot)	WP		1375 g/ha (Not specified)	[1375 g/ha] ⁸ (Cannot calculate)			
	six spotted leafhoppers	EC						
Cauliflower	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1375 g/ha (Not specified)	[1375 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	pepper weevil (maggot)	WP						
Celery	aphids, spider mites	EC, WP	Ground, equipment type not specified	1844.5 g/ha (1125 g/ha)	[1844.5 g/ha] ⁸ (1125 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafhoppers, pea moth, pea weevil, thrips	WP		1062.5 g/ha (1125 g/ha)	[1062.5 g/ha] ⁸ (1125 g/ha)			
	six-spotted leafhopper	EC		1125.7 g/ha (1125 g/ha)	[1125.7 g/ha] ⁸ (1125 g/ha)			
Cherry	fruittree leafroller	EC	Ground, equipment type not specified	[3162 g/ha] ¹¹ (Not specified)	[3162 g/ha] ^{10, 11} (Cannot calculate)	[1] ¹¹ (Not specified)	Not specified (Not applicable)	(Yes)
	black cherry aphid	EC, WP						
	mealy plum aphid, plum curculio	WP		[2812.5 g/ha] ¹¹ (Not specified)	[2812.5 g/ha] ^{10, 11} (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Corn (grain)	cereal leaf beetle	EC	Ground ULV	652.82 g/ha (1375 g/ha)	[2611.28 g/ha] ⁸ (5500 g/ha)	Not specified (4)	2 (Not specified)	(Yes)
	corn earworm, European corn borer		Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	6882.5 g/ha (5500 g/ha)	5 (4)	3 (Not specified)	
Collards	aphids	EC	Ground, equipment type not specified	1375 g/ha (1375 g/ha)	[1375 g/ha] ⁹ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafminers			1125.74 g/ha (1375 g/ha)	[1125.74 g/ha] ⁹ (1375 g/ha)			
Cranberry	blackheaded fireworm, cranberry fruitworm, leafhoppers, meadow spittlebug (nymphs)	EC	Ground, equipment type not specified	[1375 g/ha] ¹⁴ (1125 g/ha)	[1375 g/ha] ¹⁴ (1125 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
Cucumber	aphids, cucumber beetles, leafhoppers, spider mites	EC, WP	Ground, equipment type not specified	1500 g/ha (1000 g/ha)	[1500 g/ha] ¹⁰ (1000 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cabbage looper, fla beetles, imported cabbageworm	EC						
	leafminers, mites			1000 g/ha (1000 g/ha)	[1000 g/ha] ¹⁰ (1000 g/ha)			
Current	aphids, current fruit fly, leafhoppers, spider mites, thrips	WP	Ground, equipment type not specified	[625 g/ha] ¹⁴ (Not specified)	[1250 g/ha] ^{14,15} (Cannot calculate)	[2] ¹⁵ (Not specified)	[10] ¹⁶ (Not specified)	(Yes)
Dandelion	aphids	EC	Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ⁷ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
Dewberry	aphids, leafhoppers, rose chafar, spider mites, thrips	EC	Ground, equipment type not specified	[2000 g/ha] ¹² (Not specified)	[4000 g/ha] ¹² (Cannot calculate)	Not specified (2)	Not specified (7)	(Yes)
Eggplant	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1500 g/ha (1375 g/ha)	[1500 g/ha] ¹⁰ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetle, fla beetles, leafhoppers, spider mites	EC						
	pepper weevil (maggot)	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ⁹ (1375 g/ha)			
Endive	aphids, spider mites	EC, WP	Ground, equipment type not specified	1376.54 g/ha (Not specified)	[1376.5 g/ha] ^{16,17} (Cannot calculate)	[1] ¹⁴ (Not specified)	Not specified (Not applicable)	(Yes)
	cabbage looper, six-spotted leafhopper	EC		[660 g/ha] ¹⁷ (Not specified)	[660 g/ha] ^{16,17} (Cannot calculate)			
	Mexican bean beetle	WP		1375 g/ha (Not specified)	[1375 g/ha] ⁹ (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Flax	grasshoppers	EC	Ground, equipment type not specified	935 g/ha (875 g/ha)	[935 g/ha] ⁸ (875 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
			Aerial	875 g/ha (875 g/ha)	[875 g/ha] ⁸ (875 g/ha)			
Garlic	aphids, thrips	EC, WP	Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafhoppers, pea moth, pea weevil, spider mites	WP		1062.5 g/ha (1375 g/ha)	[1062.5 g/ha] ⁸ (1375 g/ha)			
Gooseberry	aphids, currant fruit fly, leafhoppers, spider mites, thrips	WP	Ground, equipment type not specified	[625 g/ha] ¹⁶ (Not specified)	[1250 g/ha] ^{16,17} (Cannot calculate)	[2] ¹⁷ (Not specified)	[10] ⁸ (Not specified)	(Yes)
Grape	aphids, scale crawlers, leafhoppers, mealybugs, spider mites	EC	Ground, equipment type not specified	1750 g/ha (1750 g/ha)	[1750 g/ha] ⁹ (1750 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	grape phylloxera (grape vines for nursery stock)		Dip solution	2.46 g/L or 1.1 g/plant (Not specified)	2.46 g/L or 1.1 g/plant (Cannot calculate)			
	multicoloured Asian lady beetle (adult)		Ground, equipment type not specified	900.6 g/ha (1750 g/ha)	900.6 g/ha (1750 g/ha)			(Yes, M)
Horseradish	aphids	EC, WP	Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cabbage looper, imported cabbageworm, pepper weevil (maggot)	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ⁹ (1375 g/ha)			
Kale	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1500 g/ha (Not specified)	[1500 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	pepper weevil (maggot)	WP		1375 g/ha (Not specified)	[1375 g/ha] ⁸ (Cannot calculate)			
Kohlrabi	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1375 g/ha (Not specified)	[1375 g/ha] ⁸ (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	pepper weevil (maggot)	WP						
Lentil	aphids, thrips	EC, WP	Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafhoppers, pea moth, pea weevil, spider mites	WP		1062.5 g/ha (1375 g/ha)	[1062.5 g/ha] ⁸ (1375 g/ha)			
Lentil	grasshoppers	EC	Ground, equipment type not specified	895.9 g/ha (1350 g/ha)	1791.8 g/ha (2700 g/ha)	2 (2)	7 (Not specified)	(Yes, M)
			Aerial	850.0 g/ha (1350 g/ha)	1700 g/ha (2700 g/ha)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ^a (Max. # of applications/season supported by registrant) ^b	Minimum interval between applications ^{a,b} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ^c	Maximum Cumulative ^c (calculated rate based on registrant information) ^d			
Lettuce	aphids, spider mites	EC, WP	Ground, equipment type not specified	1500 g/ha (1375 g/ha)	[1500 g/ha] ^e (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cabbage looper, flea beetles, imported cabbageworm, leafhoppers	EC						
	cucumber beetles							
	six-spotted leafhopper			1468.5 g/ha (1375 g/ha)	[1468.5 g/ha] ^e (1375 g/ha)			
	Mexican bean beetle	WP						
Lemonberry	aphids, leafhoppers, rose chafers, spider mites, thrips	EC	Ground, equipment type not specified	[2000 g/ha] ^f (Not specified)	[4000 g/ha] ^f (Cannot calculate)	Not specified (2)	Not specified (Not specified)	(Yes)
Melon	aphids, cucumber beetles, leafhoppers, spider mites	EC, WP	Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ^e (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafminers	EC						
Mustard	diamond back moth	EC	Aerial	454 g/ha (Not specified)	[454 g/ha] ^e (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	diamondback moth (larvae)		Ground, equipment type not specified	527 g/ha (Not specified)	[527 g/ha] ^e (Cannot calculate)			
			Aerial	425 g/ha (Not specified)	[425 g/ha] ^e (Cannot calculate)			
	flea beetles, grasshoppers		Ground, equipment type not specified Aerial	875 g/ha (Not specified)	[875 g/ha] ^e (Cannot calculate)			
Mustard (condiment type only)	grasshoppers	EC	Ground, equipment type not specified	935 g/ha (Not specified)	[935 g/ha] ^e (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
Oats	armyworms	EC	Ground, equipment type not specified Ground U.L.V. Aerial (low volume), fixed wing or rotary aircraft equipment	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ^e (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	grasshoppers winter grain mite English grain aphid		Ground, equipment type not specified Aerial (low volume), fixed wing or rotary aircraft equipment					
	cereal leaf beetle		Ground, equipment type not specified Aerial (low volume), fixed wing or rotary aircraft equipment	1100.2 g/ha (1375 g/ha)	[1100.2 g/ha] ^e (1375 g/ha)			
	greenbug grain aphids		Ground, equipment type not specified Aerial (low volume), fixed wing or rotary aircraft equipment	1468.5 g/ha (1375 g/ha)	[1468.5 g/ha] ^e (1375 g/ha)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
	aphids		Ground, equipment type not specified	1317.5 g/ha (1375 g/ha)	[1317.5 g/ha] ⁸ (1375 g/ha)			
Onion (bulb, green)	thrips	EC, WP	Ground, equipment type not specified	1185.75 g/ha (1125 g/ha)	[1185.75 g/ha] ⁸ (1125 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	aphids, leafhoppers, pea moth, pea weevil, spider mites	WP		1062.5 g/ha (1125 g/ha)	[1062.5 g/ha] ⁸ (1125 g/ha)			
Parsley	aphids	EC	Ground, equipment type not specified	1376.7 g/ha (1375 g/ha)	[1376.7 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
Parsnip	aphids	EC, WP	Ground, equipment type not specified	1449.25 g/ha (1375 g/ha)	[1449.25 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cabbage looper, imported cabageworm, pepper weevil (maggot)	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ⁸ (1375 g/ha)			
Pea	aphids	EC, WP	Ground, equipment type not specified	1125.7 g/ha (1125 g/ha)	[1125.7 g/ha] ⁸ (1125 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafhoppers, pea weevil, spider mites							
	maggots	EC						
	pea aphid			1185.75 g/ha (1125 g/ha)	[1185.75 g/ha] ⁸ (1125 g/ha)			
	pea moth	EC, WP		1125 g/ha (1125 g/ha)	[1125 g/ha] ⁸ (1125 g/ha)			
	thrips	WP		1062.5 g/ha (1125 g/ha)	[1062.5 g/ha] ⁸ (1125 g/ha)			
Peach	mites	EC	Ground, equipment type not specified	[2625 g/ha] ¹¹ (Not specified)	[2625 g/ha] ^{11,9} (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	oriental fruit moth			[3162 g/ha] ¹¹ (Not specified)	[3162 g/ha] ^{11,9} (Cannot calculate)			
	plum curculio	EC, WP						
	black cherry aphid, mealy plum aphid	WP		[2812.5 g/ha] ¹¹ (Not specified)	[2812.5 g/ha] ^{11,9} (Cannot calculate)			
Pear	aphids, tent caterpillars	EC, WP	Ground, equipment type not specified	[3750 g/ha] ¹¹ (Not specified)	[3750 g/ha] ^{11,9} (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	codling moth, fruitree leafroller, mealybugs, pear psylla, rodbanded leafroller, plum curculio			[3952.5 g/ha] ¹¹ (Not specified)	[3952.5 g/ha] ^{11,9} (Cannot calculate)			
	leafrollers, mites, pear sawfly, scale (crawlers), spider mites	EC		[3750 g/ha] ¹¹ (Not specified)	[3750 g/ha] ^{11,9} (Cannot calculate)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Pepper	aphids	EC, WP	Ground, equipment type not specified	1449.25 g/ha (1250 g/ha)	[1449.25 g/ha] ⁸ (1250 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	pepper weevil (maggot)			1375 g/ha (1250 g/ha)	[1375 g/ha] ⁹ (1250 g/ha)			
	leafhoppers pepper weevil	EC		1376.5 g/ha (1250 g/ha)	[1376.5 g/ha] ⁹ (1250 g/ha)			
	pepper maggot			[660.8 g/ha] ¹⁰ (1250 g/ha)	[2643.3 g/ha] ^{11,12} (1250 g/ha)	4 (1)	7 (Not applicable)	
	maggots			1376.5 g/ha (1250 g/ha)	[1376.5 g/ha] ⁹ (1250 g/ha)	Not specified (1)	Not specified (Not applicable)	
	cabbage looper, imported cabbageworm	WP		1375 g/ha (1250 g/ha)	[1375 g/ha] ⁹ (1250 g/ha)			
	Plum	mealy plum aphid, plum curculio		EC, WP	Ground, equipment type not specified	[3162 g/ha] ¹³ (Not specified)	[3162 g/ha] ^{13,14} (Cannot calculate)	
spider mites		EC	[2625 g/ha] ¹⁵ (Not specified)	[2625 g/ha] ^{15,16} (Cannot calculate)				
black cherry aphid		WP	[2812.5 g/ha] ¹⁷ (Not specified)	[2812.5 g/ha] ^{18,19} (Cannot calculate)				
Potato	aphids, leafhoppers	EC, WP	Ground, equipment type not specified	1185.75 g/ha (1120 g/ha)	[1185.75 g/ha] ⁸ (1120 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	Colorado potato beetle, spider mites			1125.7 g/ha (1120 g/ha)	[1125.7 g/ha] ⁸ (1120 g/ha)			
	leafminers, mites, cucumber beetle	EC		1090 g/ha (1120 g/ha)	[1090 g/ha] ⁸ (1120 g/ha)			
	tomato russet mite	WP		1062.5 g/ha (1120 g/ha)	[1062.5 g/ha] ⁸ (1120 g/ha)			
Prune plum	plum curculio	EC	Ground, equipment type not specified	[2701.8 g/ha] ¹⁷ (Not specified)	[2701.8 g/ha] ^{17,19} (Cannot calculate)	Not specified (1)	Not specified (Not applicable)	(Yes)
	mealy plum aphid spider mites			[2625 g/ha] ¹⁵ (Not specified)	[2625 g/ha] ^{15,16} (Cannot calculate)			
Pumpkin	aphids, spider mites	EC, WP	Ground, equipment type not specified	1185.75 g/ha (1000 g/ha)	[1185.75 g/ha] ⁸ (1000 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetles, leafhoppers			1062.5 g/ha (1000 g/ha)	[1062.5 g/ha] ⁸ (1000 g/ha)			
	mites leafminers	EC		1090 g/ha (1000 g/ha)	[1090 g/ha] ⁸ (1000 g/ha)			
Radish	aphids	EC, WP	Ground, equipment type not specified	1500 g/ha (1375 g/ha)	[1500 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	flea beetles, leafhoppers, Mexican bean beetle, mites	EC						
	cabbage looper, imported cabbageworm, pepper weevil (maggot)	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ⁹ (1375 g/ha)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Raspberry	bud weevil (adults)	EC, WP	Ground, equipment type not specified	[2753 g/ha] ¹² (Not specified)	[5506 g/ha] ^{12, 13} (Cannot calculate)	[2] ¹⁵ (Not specified)	[10] ¹⁶ (Not specified)	(Yes)
	leafhoppers, thrips			[2635 g/ha] ¹⁴ (Not specified)	[5270 g/ha] ^{12, 13} (Cannot calculate)			
	sap beetle	EC						
	raspberry fruitworm, raspberry sap beetle, rose chafer	WP		[2500 g/ha] ¹⁴ (Not specified)	[5000 g/ha] ^{12, 13} (Cannot calculate)			
Rutabaga	aphids	EC, WP	Ground, equipment type not specified	1349.25 g/ha (1375 g/ha)	[1449.25 g/ha] ¹⁶ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cabbage looper, imported cabbageworm			1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ¹⁶ (1375 g/ha)			
	spider mites	EC						
	pepper weevil (maggot)	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ¹⁶ (1375 g/ha)			
Rye	armyworms, grasshoppers, winter grain mite, English grain aphid	EC	Ground, equipment type not specified Aerial (low volume), fixed wing or rotary aircraft equipment	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ¹⁶ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cereal leaf beetle			1100.2 g/ha (1375 g/ha)	[1100.2 g/ha] ¹⁶ (1375 g/ha)			
	greenbug, grain aphids			1468.5 g/ha (1375 g/ha)	[1468.5 g/ha] ¹⁶ (1375 g/ha)			
	aphids		Ground, equipment type not specified	1317.5 g/ha (1375 g/ha)	[1317.5 g/ha] ¹⁶ (1375 g/ha)			
Salsify	aphids	EC, WP	Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ¹⁶ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	Mexican bean beetle, spider mites	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ¹⁶ (1375 g/ha)			
Shallot	aphids, thrips	EC, WP	Ground, equipment type not specified	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ¹⁶ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafhoppers, pea moth, pea weevil, spider mites	WP		1062.5 g/ha (1375 g/ha)	[1062.5 g/ha] ¹⁶ (1375 g/ha)			
Spinach	aphids	EC, WP	Ground, equipment type not specified	1844.5 g/ha (1750 g/ha)	[1844.5 g/ha] ¹⁶ (1750 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafminers			1750 g/ha (1750 g/ha)	[1750 g/ha] ¹⁶ (1750 g/ha)			
Squash	aphids, cucumber beetles, leafhoppers, spider mites	EC, WP	Ground, equipment type not specified	1500 g/ha (1000 g/ha)	[1500 g/ha] ¹⁶ (1000 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cabbage looper, flea beetles, imported cabbageworm	EC						
	mites			1000 g/ha (1000 g/ha)	[1000 g/ha] ¹⁶ (1000 g/ha)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ¹			
Strawberry	aphids, strawberry leafroller	EC, WP	Ground, equipment type not specified	1100 g/ha (2125 g/ha)	[2200 g/ha] ³ (4250 g/ha)	Not specified (2)	[10] ⁸ (Not specified)	(Yes)
	leafhoppers	EC						
	spider mites			1000 g/ha (2125 g/ha)	[2000 g/ha] ³ (4250 g/ha)			
	leafrollers	WP		1062.5 g/ha (2125 g/ha)	[2125 g/ha] ³ (4250 g/ha)			
	strawberry root weevil (BC only)	EC		2125 g/ha post harvest rate and 1976.25 g/ha pre-harvest rate (2125 g/ha)	[4250 g/ha] ³ post harvest rate and [3952.5 g/ha] ³ pre-harvest rate (4250 g/ha)			
Sugar beet	flea beetles	EC	Ground, equipment type not specified	550 g/ha (550 g/ha)	[550 g/ha] ³ (550 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
Swiss chard	aphids	EC	Ground, equipment type not specified	1375 g/ha (1375 g/ha)	[1375 g/ha] ³ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafminers			1125.74 g/ha (1375 g/ha)	[1125.74] ³ (1375 g/ha)			
Tobacco	aphids	EC	Ground, equipment type not specified	1054 g/ha (1000 g/ha)	[1054 g/ha] ³ (1000 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafhoppers, tobacco hornworm			1000 g/ha (1000 g/ha)	[1000 g/ha] ³ (1000 g/ha)			
Tomato	aphids, leafhoppers, tomato russet mite	EC, WP	Ground, equipment type not specified	1062.5 g/ha (1000 g/ha)	[1062.5 g/ha] ³ (1000 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetles, leafminers, mites	EC		1000 g/ha (1000 g/ha)	[1000 g/ha] ³ (1000 g/ha)			
	spider mites	EC, WP		1185.75 g/ha (1000 g/ha)	[1185.75 g/ha] ³ (1000 g/ha)			
	Colorado potato beetle	EC		1062.5 g/ha (1000 g/ha)	[1062.5 g/ha] ³ (1000 g/ha)			
Turnip	aphids, cabbage looper, imported cabbageworm	EC, WP	Ground, equipment type not specified	1500 g/ha (1375 g/ha)	[1500 g/ha] ³ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	cucumber beetles, flea beetles, leafhoppers, spider mites	EC						
	pepper weevil (maggot)	WP		1375 g/ha (1375 g/ha)	[1375 g/ha] ³ (1375 g/ha)			
Watercress	aphids	EC	Ground, equipment type not specified	1375 g/ha (1375 g/ha)	[1375 g/ha] ³ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	leafminers			1125.74 g/ha (1375 g/ha)	[1125.74 g/ha] ³ (1375 g/ha)			

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Wheat	armyworms	EC	Ground, equipment type not specified. Ground ULV Aerial (Low volume), fixed wing or rotary aircraft equipment	1376.5 g/ha (1375 g/ha)	[1376.5 g/ha] ⁸ (1375 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
	grasshoppers, winter grain mite, English grain aphid		Ground, equipment type not specified. Aerial (low volume), fixed wing or rotary aircraft equipment					
	cereal leaf beetle			1100.2 g/ha (1375 g/ha)	[1100.2 g/ha] ⁸ (1375 g/ha)			
	greenbug, grain aphids			1468.5 g/ha (1375 g/ha)	[1468.5 g/ha] ⁸ (1375 g/ha)			
	aphids		Ground, equipment type not specified	1317.5 g/ha (1375 g/ha)	[1317.5 g/ha] ⁸ (1375 g/ha)			
Wild rice (cultivated)	wild rice worm	EC	Ground, knapsack or similar applicator equipment. Aerial	1125.7 g/ha (1125 g/ha)	[1125.7 g/ha] ⁸ (1125 g/ha)	Not specified (1)	Not specified (Not applicable)	(Yes)
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Bakeries, Canneries, Meat processing plants	flies, hornets, mosquitoes, wasps	EC	Spray, equipment type not specified	1000 g/100 L water or 90 g in 51/100 m ³ (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
	flour beetles, granary weevil, rice weevil			325 g/10 L water (Not applicable)				
Barns, Pig pens, Outbuildings	chicken red mite, flies, northern fowl mite, poultry lice	EC	Spray or as a paint, equipment not specified	105.4 g/10 L (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
	ticks			290.7 g/10 L (Not applicable)				

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ⁵	Maximum Cumulative ⁵ (calculated rate based on registrant information) ⁵			
Dairies	ants	SN	Pressure spray, equipment type not specified Paint, paint brush	122 g in 5 L / 100 m ² (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
		EC	Spray, equipment type not specified	30 g/L (Not applicable)				
	cockroaches, crickets, earwigs, flies, grain insects, lice, mites, mosquitoes, silverfish, springtail, weevils	SN	Pressure spray, equipment type not specified Paint, paint brush	122 g in 5 L, water / 100 m ² (Not applicable)				
		EC	Spray, equipment type not specified	10.54 g/L (Not applicable)				
	spiders	SN	Pressure spray, equipment type not specified Paint, paint brush	122 g in 5 L, water / 100 m ² (Not applicable)				
		EC	Spray, equipment type not specified	30 g/L (Not applicable)				
	clover mite, grasshoppers, millipedes, spiders, sowbugs							
Dairy barn	flies, hornets, mosquitoes, wasps	EC	Spray, equipment type not specified	1000 g/100 L of water (50 g in 5 L/100 m ²) (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
	ants, cockroaches, silverfish, spiders		Coarse spray, equipment type not specified Paint, paint brush	32.5 g/L water or kerosene-type solvent (Not applicable)				
Dwellings foundations	ants, cockroaches, silverfish, spiders	EC	Pressure spray, equipment type not specified Paint, paint brush	32.5 g/L water or kerosene-type solvent (Not specified)	Cannot calculate (Cannot calculate)	Not specified (Not specified)	Not specified (Not specified)	(Partial Use in indoor dwellings not supported by registrant. Outdoor foundation and spot perimeter treatment spraying are supported by registrant)
Farm buildings (indoor)	house fly, mosquitoes, stable fly	EC	Spray (addition of sugar (4 kg/ 100 L or molasses 2.5 L/100 L) as a fly attractant), equipment type not specified	10 g/10 L or 100 g/ 100 m ² (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
			Spray, equipment type not specified	10 g/L or 100 g/ 100 m ² (Not applicable)				
			Spray (attractants such as molasses, syrup or sugar may be used at a rate of 10 L/500 L water), equipment type not specified	10.68 g/L (Not applicable)				

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ¹ (Max. # of applications/season supported by registrant) ¹	Minimum interval between applications ^{2,3} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ⁴	Maximum Cumulative ² (calculated rate based on registrant information) ⁴			
	lice		Spray (addition of sugar 4 kg/100 L or molasses 2.5 L/100 L as a fly attractant, equipment type not specified)	10 g/10 L or 100 g/100 m ² (Not applicable)				
			Spray (attractants such as molasses, syrup or sugar may be used at a rate of 10 L/500 L water), equipment type not specified	10.68 g/L, (Not applicable)				
Flour mills	ants, cockroaches, crickets, earwigs, flies, grain insects, lice, mites, mosquitoes, silverfish, spiders, springtail, weevils	SN	Pressure spray, equipment type not specified. Paint, paint brush	122 g in 5 L water / 100 m ² (Not specified)	Cannot calculate (Cannot calculate)	Not specified (Not specified)	Not specified (Not specified)	(Yes)
		EC	Spray, equipment type not specified	1054 g/100 L (Not specified)				
	confused flour beetle, flat grain beetle, grain mites, Indian meal moth, lesser grain borer, red flour beetle, rusty grain beetle, sawtoothed grain beetle		Broadcast, crack and crevice spray, equipment type not specified	167.2 g in 5 L of water or deodorized kerosene /100 m ² (Not specified)				
	granary weevil, rice weevil		Spray, equipment type not specified	32.5 g/L (Not specified)				
			Pressure spray, equipment type not specified. Paint, paint brush	122 g in 5 L water /100 m ² (Not specified)				
			Broadcast, crack and crevice spray, equipment type not specified	167.2 g in 5 L of water or deodorized kerosene /100 m ² (Not specified)				
	flour beetles		Spray, equipment type not specified	32.5 g/10 L water (Not specified)				
	beekhouse, carpet beetles, clothes moths, spiders		Broadcast surface spray, equipment type not specified	1054 g/100 L of water (Not specified)				
	hornets, wasps			1000 g/100 L or 50 g in 5 L/100 m ² (Not specified)				
Food mills	flies, hornets, mosquitoes, wasps	EC	Broadcast surface spray, equipment type not specified	1000 g/100 L water or 50 g in 5 L/100 m ² (Not specified)	Cannot calculate (Cannot calculate)	Not specified (Not specified)	Not specified (Not specified)	(Yes)
	flour beetles, granary weevil, rice weevil			32.5 g/10 L water (Not specified)				

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant		
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³					
Food processing plants	ants, spiders	EC	Coarse spray, equipment type not specified. Paint, paint brush	32.5 g/l. water or kerosene-type solvent (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)		
			Spray, equipment type not specified	30 g/l. (Not applicable)						
		SN	Pressure spray, equipment type not specified. Paint, paint brush	122 g in 5 L/100 m ² (Not applicable)						
	cockroaches, silverfish, spiders	EC	Coarse spray, equipment type not specified. Paint, paint brush	32.5 g/l. water or kerosene-type solvent (Not applicable)						
			Spray, equipment type not specified	1054 g/100 L. (Not applicable)						
		SN	Pressure spray, equipment type not specified. Paint, paint brush	122 g in 5 L/ 100 m ² (Not applicable)						
	crickets, earwigs, flies, grain insects, lice, mites, mosquitoes, silverfish, spiders, springtail, weevils	EC	Spray, equipment type not specified	1054 g/100 L. (Not applicable)						
		SN	Pressure spray, equipment type not specified. Paint, paint brush	122 g in 5 L/ 100 m ² (Not applicable)						
	hornets wasps	EC	Spray, equipment type not specified	1000 g /100 L. water or 50 g/ 100 m ² (Not applicable)					9 (Not applicable)	
	grasshoppers, millipedes, sowbugs		Spray, equipment type not specified	30 g/l. of water or deodorized kerosene (Not applicable)						
	clover mite (exterior wall surface)									Not specified (Not applicable)
	booklouse, carpet beetles, clothes moth			1054 g/100 L. of water (Not applicable)						
Outside foundations	ants, clover mite, grasshoppers, millipedes, sowbugs	EC	Coarse spray, equipment type not specified. Paint, paint brush	30 g/l. water (Not specified)	Cannot calculate (Cannot calculate)	Not specified (Not specified)	9 (Not specified)	(Partial. Outdoor foundation and spot perimeter treatment spraying are supported by registrant)		

Site(s)	Pest (s)	Formulation Type	Application Methods and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁶ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
Poultry houses and shipping crates	chicken red mite, flies, poultry lice, northern fowl mite	EC	Spray, equipment type not specified. Paint, paint brush	105.4 g/10 L. (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)
	chicken mite		Spray, equipment type not specified	100 g/10 L. (Not applicable)				
	lice			300 g/10 L. (Not applicable)				
	ticks		Spray, equipment type not specified. Paint, paint brush	250.7 g/10 L. (Not applicable)				
USC 25 Human Habitat and Recreational Areas								
Farm yards, Pens, Feedlots, Pastures, Stabling areas, Manure piles, Garbage areas, Around buildings and undergrowth	house fly, mosquitoes, stable fly	EC	Ground (2% space spray, mist or fog), equipment type not specified	818.7 g/ha (Not applicable)	Cannot calculate (Not applicable)	Not specified (4)	Not specified (Not applicable)	(No) ⁹
			Ground ULV, cold aerosol applicator	658.75 g/ha (Not applicable)				
			Ground, Fog, aerosol, or space spray, equipment type not specified	550 g/ha water or oil (Not applicable)				
	small flying insects		Ground (2% space spray, mist or fog), equipment type not specified	818.7 g/ha (Not applicable)				
			Ground ULV, cold aerosol applicator equipment	658.75 g/ha (Not applicable)				
Outdoor areas (In and around buildings housing domestic animals, around yards, around processing plants and around other buildings)	house fly, stable fly		Ground spray or spray baited with sweetening agents (molasses or sugar), equipment type not specified	105.4 g/100 L. or 52.7 g/100 m ² painted surface 105.4 g/100 m ² unpainted surface (Not specified)	[210.8 g/100 m ² painted surface 421.6 g/100 m ² unpainted surface] ⁸ (Not specified)	Not specified (4)	Not specified (7)	(Yes)
Municipal dumps, Refuse areas, Sewage lines	cockroaches		Ground, equipment type not specified	30.7 g/l. of oil or water (Not applicable)	Cannot calculate (Not applicable)	Not specified (Not applicable)	Not specified (Not applicable)	(No)

Site(s)	Pest (s)	Formulation Type	Application Method and Equipment	Application rate (g a.i.)		Max. # of applications/season ⁴ (Max. # of applications/season supported by registrant) ⁵	Minimum interval between applications ^{6,7} (days)	Use Supported by registrant
				Maximum single (max. single supported by registrant) ¹	Maximum Cumulative ² (calculated rate based on registrant information) ³			
USC 27 - Ornamentals (Outdoors)								
Ornamentals	aphids, mealybugs, spider mites, thrips	EC, WP	Ground, equipment type: not specified	1500 g/ha (Not specified)	[6000 g/ha] ⁸ (Cannot calculate)	Not specified (4)	[10] ⁹ (7)	(Yes)
	codling moth, four lined plant bug, grasshoppers (young), Japanese beetle, native scale, whiteflies	EC		[1054 g/ha] ¹⁰ (Not specified)	[4216 g/ha] ⁸ (Cannot calculate)			
	bagworm, lace bugs, leafhoppers, leafminers, scales (crawlers), shoot moths, tarnished plant bug, tent caterpillars			1500 g/ha (Not specified)	[6000 g/ha] ⁸ (Cannot calculate)			
	hitchhiker, leafminers, boxwood leafminer, oystershell scale			[1317.5 g/ha] ¹⁰ (Not specified)	[5270 g/ha] ⁸ (Cannot calculate)			
	fungus gnats, mites	EC		[1250 g/ha] ¹⁰ (Not specified)	[5000 g/ha] ⁸ (Cannot calculate)			
	European pine shoot moth, pine needle scale, plant bugs, sawflies, scale insects			1375 g/ha or 15 g/100 m ² (Not specified)	[5500 g/ha] ⁸ or [6000 g/ha] ⁸ (Cannot calculate)			
	spruce budworm			3000 g/ha (Not specified)	[12 000 g/ha] ⁸ (Cannot calculate)			
	pine needle scale			2635 g/ha (Not specified)	[10 540 g/ha] ⁸ (Cannot calculate)			
	greenhouse whitefly	WP		1250 g/ha (Not specified)	[5000 g/ha] ⁸ (Cannot calculate)			
USC 33 - Residential Outdoors								
Garden areas and yards	ants, clover mite, grasshoppers, millipedes, sowbugs, spiders	EC	Ground, equipment type: not specified	30 g/l. (Not specified)	Cannot calculate (Cannot calculate)	Not specified (4)	9 (Not specified)	(Partial Registrant supports use in garden areas but not in yards)

g a.i. = grams of active ingredient.

Formulation designations are based on PMRA's Oracle database (DU = Dust, EC = Emulsifiable Concentrate or Emulsion, LI = Liquid, SN = Solution, WP = Wettable Powder).

M = use was registered as an URMULE.

USC = Use Site Category.

Information in square brackets [] is based upon PMRA's assumptions. See footnotes for further information.

1. Text in *(Italics)* is used to indicate the maximum single application rate supported by the registrant Cheminova.

2. The maximum cumulative rate is the calculated rate based on information on labels.

3. The *(maximum cumulative rate)* is the calculated rate based on information from registrant Cheminova.

4. Maximum number of applications/season is based on information from labels. For a site, if all labels did not have a maximum number of applications/season then it is recorded as "Not specified".

5. (*Maximum number of applications/season*) is based on information provided by registrant Cheminova.
6. If a minimum interval between applications was not specified on labels, and Cheminova has specified support for one application per season, then the minimum interval between applications is recorded as "Not applicable".
7. (*Minimal interval between applications supported by registrant Cheminova*).
8. The minimum interval is based on labels that indicate an interval but also included statement "or as required" therefore the minimum interval was used in calculations. Also, if labels for a site had an interval for a pest but not for other pests on the site the same interval was assumed for pests where information was missing.
9. If a maximum number of applications/season was not specified on any of the labels but the registrant Cheminova has indicated the maximum number of applications/season supported for the site this was used to calculate maximum cumulative rate.
10. Assumed spray volume of 1000 L/ha for large ornamental plants. This assumption was used for outdoor ornamentals (USC 27) and greenhouse ornamentals (USC 6).
11. Assumed spray volume of 3000 L/ha.
12. Assumed spray volume of 2000 L/ha.
13. The registrant Cheminova supported one application/season for other stone fruits (nectarines, peaches and plums) therefore, it is assumed that cherries which have a similar growing season would also have one application per season.
14. Assumed spray volume of 1000 L/ha.
15. The registrant Cheminova supported two applications/season for blackberry, boysenberry, dewberry and loganberry, therefore, it is assumed that currants and raspberry would have the same number of applications per season.
16. The registrant Cheminova supported one application/season for other leafy vegetables including lettuce, therefore, it is assumed that endive would also have one application per season.
17. Assumed spray volume of 450 L/ha.
18. If the maximum number of applications per season is not specified for a pest for a site but is specified on the labels for another pest on the same site, the PMRA assumed the same number of applications per season.
19. In October 2008 the registrant Cheminova indicated that they no longer support use of fog, aerosol, mist, space spray and ground ULV to control house fly, mosquitoes, stable fly and small flying insects on listed sites.

Appendix IIb Registered Domestic Class uses of malathion in Canada as of April 10, 2008. The following are uses of products formulated with malathion only. All products are Emulsifiable Concentrate or Emulsions (EC)¹

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
USC 14 - Terrestrial food crops					
Apple	aphids, codling moth, mites	Ground; equipment type not specified	0.52 - 2.47 g/L	Not specified	Yes
	leafhoppers, scale crawlers, spider mites, strawberry root weevil (adult, BC only)		0.52 - 1.0 g/L		
	fruit tree leafroller, mealybug, red-banded leafroller, tent caterpillars		1.48 - 2.47 g/L		
Apricot	aphids, codling moth, leafhoppers, mites, scale crawlers, spider mites, strawberry root weevil (adult, BC only)	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes
Bean	aphids, cabbage looper, leafhoppers, leafminers	Ground; equipment type not specified	0.52 - 2.96 g/L	Not specified	Yes
	cabbageworms, Colorado potato beetle, cucumber beetle, flea beetle, Mexican bean beetle, spider mites		2.96 g/L		
	imported cabbageworm, mites, pea moth, pea weevil, potato beetles		0.52 - 1.0 g/L		
Broccoli	aphids, cabbage looper, imported cabbageworm, leafhoppers, leafminers, mites, pea moth, pea weevil, potato beetles	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Brussels sprouts	aphids, cabbage looper, imported cabbageworm, leafhoppers, leafminers, mites, pea moth, pea weevil, potato beetles	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes
Cabbage	aphids, cabbage looper, imported cabbageworm, leafhoppers, leafminers, mites, pea moth, pea weevil, potato beetles	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes
Celery	aphids, cabbage looper, imported cabbageworm, leafhoppers, leafminers, mites, pea moth, pea weevil, potato beetles	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes
Cherry	aphids, codling moth, fruit tree leafroller, mealybugs, mites, red-banded leafroller, tent caterpillars	Ground; equipment type not specified	1.48 - 2.47 g/L	Not specified	Yes
Cucumber	aphids, leafhoppers, leafminers, spider mites, Mexican bean beetle, Colorado potato beetle, flea beetles, cucumber beetle, cabbage looper, cabbageworms	Ground; equipment type not specified	2.96 g/L	Not specified	Yes

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Fruit	aphids, bagworm, beetles, bud moths, cabbageworms, caterpillars, codling moth, currant fruitworm, fruit moths, lace bugs, leafhoppers, leafminers, leafrollers, mealybugs, mites, pine shoot moth, pear psylla, plant bugs, plum curculio, potato beetles, raspberry fruitworm, tent caterpillars, whitefly	Ground; equipment type not specified	1.75 g/ L	Not specified	Yes
		Ground; hose-end applicator	Cannot calculate		
Fruit trees	aphids, caterpillars, codling moth, lace bugs, leafhoppers, mealybugs, scales, spider mites, tarnished plant bug, thrips	Ground; equipment type not specified	0.75 g/L	Not specified	Yes
Grape	aphids, codling moth, leafhoppers, mites, scale crawlers, spider mites, strawberry root weevil (adult, BC only)	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes
Lettuce	aphids, cabbage looper, imported cabbageworm, leafhoppers, leafminers, mites, pea moth, pea weevil, potato beetles	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Pea	aphids, leafhoppers, leafminers, cabbage looper	Ground; equipment type not specified	0.52 - 2.96 g/L	Not specified	Yes
	imported cabbageworm, mites, pea moth, pea weevil, potato beetles		0.52 - 1.0 g/L		
	cabbageworms, Colorado potato beetle, cucumber beetle, flea beetles, Mexican bean beetle, spider mites		2.96 g/L		
Peach	aphids, codling moth, mites	Ground; equipment type not specified	0.52 - 2.47 g/L	Not specified	Yes
	leafhoppers, scale crawlers, spider mites, strawberry root weevil (adult, BC only)		0.52 - 1.0 g/L		
	fruit tree leafroller, mealybugs, red-banded leafroller, tent caterpillars		1.48 - 2.47 g/L		
Pear	aphids, codling moth, mites	Ground; equipment type not specified	0.52 - 2.47 g/L	Not specified	Yes
	leafhoppers, scale crawlers, spider mites, strawberry root weevil (adult, BC only)		0.52 - 1.0 g/L		
	fruit tree leafroller, mealybugs, red-banded leafroller, tent caterpillars		1.48 - 2.47 g/L		
Plum	aphids, codling moth, fruit tree leafroller, mealybugs, mites, red banded leafroller, tent caterpillars	Ground; equipment type not specified	1.48 - 2.47 g/L	Not specified	Yes

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Potato	aphids, cabbage looper, leafhoppers, leafminers	Ground; equipment type not specified	0.52 - 2.96 g/L	Not specified	Yes
	cabbageworms, cucumber beetle, Colorado potato beetle, flea beetles, Mexican bean beetle, spider mites		2.96 g/L		
	imported cabbageworm, mites, pea moth, pea weevil, potato beetles		0.52 - 1.0 g/L		
Radish	aphids, leafhoppers, leafminers, spider mites, Mexican bean beetle, Colorado potato beetle, flea beetles, cucumber beetle, cabbage looper, cabbageworms	Ground; equipment type not specified	2.96 g/L	Not specified	Yes
Spinach	aphids, cabbage looper, imported cabbageworm, leafhoppers, leafminers, mites, pea moth, pea weevil, potato beetles	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes
Strawberry	aphids, codling moth, leafhoppers, mites, scale crawlers, spider mites, strawberry root weevil (adult, BC only)	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Tomato	aphids, cabbage looper, leafhoppers, leafminers,	Ground; equipment type not specified	0.52 - 2.96 g/l.	Not specified	Yes
	imported cabbageworm, mites, pea moth, pea weevil, potato beetles		0.52 - 1.0 g/l.		
	cabbageworms, cucumber beetle, Colorado potato beetle, flea beetles, Mexican bean beetle, spider mites		2.96 g/l.		
Turnip	aphids, cabbage looper, imported cabbageworm, leafhoppers, leafminers, mites, pea moth, pea weevil, potato beetles	Ground; equipment type not specified	0.52 - 1.0 g/l.	Not specified	Yes
Vegetables	aphids, caterpillars, codling moth, lace bugs, leafhoppers, mealybugs	Ground; equipment type not specified	0.75 - 1.75 g/l.	Not specified	Yes
		Ground; hose-end applicator	Cannot calculate		
	bagworm, beetles, bud moths, cabbageworms, currant fruitworm, fruit moths, leafminers, leafrollers, mites, pine shoot moth, pear psylla, plant bugs, plum curculio, potato beetles, raspberry fruitworm, tent caterpillars, whitefly	Ground; equipment type not specified	1.75 g/l.		
		Hose-end applicator	Cannot calculate		
	grasshoppers (young)	Ground; equipment type not specified	1.0 g/l.		
	scales, spider mites, tarnished plant bug, thrips		0.75 g/l.		

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Structural (USC 20)					
Foundations	ants, clover mite, grasshoppers, millipedes, spiders, sow bugs	Ground; equipment type not specified	29.6 g/L	9	Yes
Foundations, exterior wall surfaces, under fences and shrubs	mosquitoes	Ground; equipment type not specified	0.515 g/L	9	Yes
Ornamental Outdoor (USC 27)					
Flowers	aphids, bagworm, beetles, bud moths, cabbageworms, caterpillars, codling moth, currant fruitworm, fruit moths, lace bugs, leafhoppers, leafminers, leafrollers, mealybugs, mites, pine shoot moth, pear psylla, plant bugs, plum curculio, potato beetles, raspberry fruitworm, tent caterpillars, whitefly	Ground; equipment type not specified	1.75 g/L	Not specified	Yes
Flowers, shrubs, shade trees	aphids, caterpillars, codling moth, lace bugs, leafhoppers, mealybugs, scales, spider mites, tarnished plant bug, thrips	Ground; equipment type not specified	0.75 g/L	Not specified	Yes
	young grasshoppers		1.0 g/L		
	maple bladder gall mite		1.5 g/L	14	
	spruce budworm			5	
Garden area	ants, clover mite, grasshoppers, millipedes, spiders, sow bugs	Ground; equipment type not specified	29.6 g/L	9	Yes

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Ornamentals	beetles, bud moths, cabbageworms, caterpillars, codling moth, currant fruitworm, fruit moths, leafhoppers, leafrollers, mites, pine shoot mite, pear psylla, plant bugs, plum curculio, potato beetles, raspberry fruitworm, whitefly	Ground; equipment type not specified	1.75 g/L	Not specified	Yes
		Ground; hose-end application	Cannot calculate		
	aphids, bagworm, lace bugs, leafminers, mealybugs, tent caterpillars	Ground; equipment type not specified	1.48 - 2.96 g/L		
		Ground; hose-end applicator	Cannot calculate		
	European shoot moth, pine needle scale, spider mites, thrips	Ground; equipment type not specified	1.48 - 2.96 g/L		
	spruce budworm		3.5 g/L		
Ornamentals (shrubs)	mosquitoes	Ground; equipment type not specified	10.5 g/3 l / 40 m ²	Not specified	Yes
Outdoor flowers, ornamentals, trees and shrubs	aphids, lace bugs, leafhoppers, leafminers, scales, spider mites, tent caterpillars, thrips, whitefly	Ground; equipment type not specified	0.52 - 1.0 g/L	Not specified	Yes
Spruce, Fir	spruce budworm	Ground; equipment type not specified	2.96 g/L	5	Yes
Turf (USC 30)					
Exterior walls and around buildings	ants, clover mites, millipedes	Ground; equipment type not specified	31.5 g/L	Not specified	Partial. Registrant does not support broadcast turf/lawn treatment. Foundation/spot perimeter treatment is supported
House foundations, exterior wall surfaces, under fences and shrubs	mosquitoes	Ground; equipment type not specified	0.515 g/L	9	

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)	Use supported by registrant
Residential outdoors (USC 33)					
Exterior walls and around buildings	ants, clover mite, millipedes	Ground; equipment type not specified	31.5 g/L	Not specified	Yes
Outside	ants, clover mites, grasshoppers, millipedes, spiders, sowbugs	Ground; equipment type not specified	15.45 g/L	Not specified	Yes
House foundations, exterior wall surfaces, under fences and shrubs	mosquitoes	Ground; equipment type not specified	0.515 g/L	9	<i>Partial. Registrant does not support broadcast turf/lawn treatment. Foundation/spot perimeter treatment is supported</i>

a.i. = active ingredient, EC = Emulsifiable Concentrate or Emulsion, USC = Use Site Category

1. The maximum number of applications per year is not listed on any labels, therefore the cumulative application rate per year could not be calculated.

Appendix IIc Registered Domestic Class uses of malathion as of April 11, 2008. The following uses of products formulated with malathion and fungicide active ingredients. All products are dust formulations and are supported by the registrant¹

Site	Pest(s)	Application Methods and Equipment	Single Application Rate (a.i.)	Minimum Interval between applications (days)
USC 14- Terrestrial food crops				
Apple, Apricot, Blackberry, Cherry, Cucumber, Pepper, Strawberry, Tomato	most diseases and insects	Ground, hose-end applicator	1.0 g/L	10
		Ground, compressed air sprayer	0.5 g/L	
		Ground, dust	Cannot calculate	
USC 27 - Ornamentals (Outdoor)				
Ornamentals	most diseases and insects	Ground, hose-end applicator	1.0 g/L	10
		Ground, compressed air sprayer	0.5 g/L	
		Ground, dust	Cannot calculate	
Ornamental flowers and shrubs, roses, evergreens, and conifers	<u>insects:</u> aphids, leafhoppers, leafminers, mites, other chewing insects rose chafers, sawflies, spruce budworm, tent caterpillars <u>diseases:</u> blackspot, blight on juniper powdery mildew on roses, flowers and ornamentals	Ground, <u>squeeze container to apply a light coating to upper and lower leaf surfaces</u>	Cannot calculate	Not specified
Roses and other flowers and ornamentals	<u>insects:</u> aphids, caterpillars, flea beetles, leafhoppers, leafminers, leafrollers, loopers, mites, rose chafer, scale insects (crawler stage only) tarnished plant bug, thrips, young grasshoppers <u>diseases:</u> black spot of roses, powdery mildew, Anthracnose	Ground, <u>squeeze container to apply a light coating to upper and lower leaf surfaces</u>	Cannot calculate	7

a.i. = active ingredient, USC = Use Site Category

1. The maximum number of applications per year is not listed on any labels, therefore the cumulative application rate per year cannot be calculated.

Appendix III Toxicology

Table 1 Toxicological Endpoints for Malathion Health Risk Assessment

	RfD (mg/kg bw)	Study NOAEL or BMD	CAF or Target MOE and Rationale
ARD females aged 13-49	0.08	NOAEL: 25 mg/kg bw/day Rabbit Developmental Toxicity (Resorptions)	300 PCPA=3-fold
ARD general population including children	0.23	BMDL ₂₀ : 23 mg/kg bw/day Acute Malathion: Malaoxon Comparative (1 EChE after single dose)	100 PCPA = 1-fold
ADI general population including children and females aged 13-49	0.03	NOAEL: 3 mg/kg bw/day Rat chronic/carcinogenicity study (chronic nephropathy)	100 PCPA = 1-fold
Non-dietary oral ingestion by children		NOAEL: 5 mg/kg bw/day Rat, DNT Study (↓ motor activity)	100 PCPA = 1-fold
short-term dermal intermediate dermal general population²		NOAEL: 25 mg/kg bw/day Rabbit Developmental Toxicity (Resorptions)	300 Concern for unborn child =3-fold (occupational) PCPA=3-fold (residential)
short-term dermal intermediate dermal children		BMDL ₂₀ : 107 mg/kg bw/day Rabbit, 21-day Dermal Study (1 EChE)	300 (PCPA = 3-fold)
long-term dermal occupational (not including children)²		NOAEL: 3.0 mg/kg bw/day 2-yr Oral Rat Study (chronic nephropathy)	100
short- term intermediate- term inhalation general population (including children) (occupational and residential)		LOAEL: 25.8 mg/kg bw/day Rat, 90-day Inhalation Study (nasal lesions)	1000 (10-fold for use of a LOAEL.) PCPA=1-fold (residential)

	RfD (mg/kg bw)	Study NOAEL or BMD	CAF or Target MOE and Rationale
long-term inhalation occupational		LOAEL: 25.8 mg/kg bw/day Rat, 90-day inhalation study (nasal lesions)	1000 (10-fold for use of a LOAEL.)
acute aggregate, general population (incl. children)		Endpoint: 1EChE BMDL ₂₀ : 23 mg/kg bw/day Rat, Acute Malathion:Malaoxon Comparative	100 PCPA = 1-fold
acute aggregate, females 13-49		Endpoint: Resorptions NOAEL: 25 mg/kg bw/day Rabbit, Developmental Toxicity	300 PCPA=3-fold
short-term aggregate children^{2,3}		Endpoint: 1 motor activity NOAEL: 5 mg/kg bw/day Rat, DNT Study	100 PCPA = 1-fold
short-term aggregate females 13-49^{2,3}		Endpoint: Resorptions NOAEL: 25 mg/kg bw/day Rabbit, Developmental Toxicity	300 PCPA=3-fold
short-term aggregate general population		Endpoint: 1EChE Oral BMDL ₂₀ : 23 mg/kg bw/day Rat, Malathion:Malaoxon Comparative Dermal BMDL ₂₀ : 107 mg/kg bw/day Rabbit, 21-day Dermal Study Inhalation NOAEL: 25.8 mg/kg bw/day Rat, 90-day Inhalation Study	100100100

¹CAF (Composite assessment factor) refers to the total of uncertainty and PCPA factors for dietary risk assessments, MOE refers to target MOE for occupational assessments

²Since an oral NOAEL was selected, a dermal absorption factor of 10% is used in a route-to-route extrapolation.

³Since an oral NOAEL was selected, an inhalation absorption factor of 100% (default value) is used in route-to-route extrapolation.

Table 2 Toxicology Profile for Malathion

NOTE: Depression of PChE is not considered by PMRA to be a toxicologically adverse effect; it can be viewed as a marker of exposure. Depression of EChE can be viewed as a surrogate for adverse changes in the peripheral nervous tissue in acute and some short-term studies. In studies of longer duration, depression of EChE is not considered by PMRA to be a toxicologically adverse effect.

NOTE: All effects noted below are known or assumed to occur in both sexes unless otherwise specified.

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
Metabolism/Toxicokinetic Studies			
Absorption, Distribution, Metabolism, Excretion Sprague-Dawley Rat 5/sex/group	¹⁴ C-labelled (98% purity) malathion by oral gavage at 40 or 800 mg/kg bw or 40 mg/kg bw unlabelled malathion (94.6% pure) for 15 doses followed by 16 th dose of ¹⁴ C- malathion		<u>Absorption:</u> Malathion is readily absorbed following oral exposure. Peak plasma levels of malathion occur 15 minutes post dosing. <u>Distribution:</u> Malathion is rapidly distributed. At 72 hours, the highest concentration of radioactivity was observed in the liver. ¹⁴C-labelled malathion did not bioaccumulate in any of the organ/tissues analysed. <u>Metabolism:</u> Malathion is fully metabolized with no parent compound present in the urine. Greater than 80% of the radioactivity in urine was identified as the diacid (DCA) and monoacid (MCA) metabolites. The major metabolic pathway involves the hydrolysis of the carboxyester by tissue, liver or plasma carboxylesterases, resulting in alpha and beta monocarboxylic acid. A proposed metabolic pathway postulates the oxidative desulphuration of malathion by microsomal enzymes to malaaxon which is excreted in the urine or further metabolised by phosphatases. Between 4 and 6% of the administered dose was converted to malaaxon, the active cholinesterase inhibiting metabolite of malathion. Other minor metabolites detected included 0,0-dimethyl phosphorothioic acid and desmethyl malathion, 0,0-dimethylphosphorothiolate, 2-mercapto-succinic acid, fumaric acid and monothylfumarate. <u>Excretion:</u> Excretion occurs primarily via the urine (76-88%) with a lesser amount excreted in faeces (6-14%) within 72 hours of dosing in the rat. Excretion profile similar for single or repeat low dose or single high dose administration. No sex difference in excretion profile.
Acute Toxicity Studies			
Acute oral toxicity Mouse	95% purity		LD50 = 6100 mg/kg bw (♀)
Acute oral toxicity Sprague-Dawley Rat	96-98% purity 99.1% purity		LD50 = 5000-6156 mg/kg bw (♂); 4061-5700 mg/kg bw (♀) Clinical signs typical of cholinesterase inhibition (including piloerection, abnormal gait, pallor of extremities, increased salivation) LD50 = 8200 mg/kg bw (♂/♀)
Acute oral toxicity Wistar Rat	92.2% purity 98.2% purity		LD50 = 1580 mg/kg bw (♂/♀) LD50 = 8000 mg/kg bw (♂/♀)
Acute oral toxicity Leghorn Hen	93.6% purity		LD50 = 610-984 mg/kg bw (♀)
Acute oral toxicity Dog	98% purity		LD50 > 4000 mg/kg bw
Acute dermal toxicity Sprague-Dawley Rat	96-98% purity		LD50 = 2000 mg/kg bw No mortalities, clinical signs of toxicity. No dermal irritation noted at site of treatment.
Acute dermal toxicity NZW Rabbit	95.6% purity		LD50 = 8900 mg/kg bw Erythema and edema noted in all test animals, with recovery at 5000 mg/kg bw by day 5; persisting to end of study at 10000 mg/kg bw. Decreased locomotor activity at 10000 mg/kg bw.
Acute inhalation toxicity Wistar Rat	96-98% purity nose-only exposure for 4 hr		LC50 > 5.2 mg/L No mortalities but clinical signs typical of cholinesterase inhibition were observed.

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
Eye irritation N/ZW Rabbit	96-98% purity; 0.1 mL	Slight conjunctival irritation; resolved by day 7.	
Skin irritation N/ZW Rabbit	96-98% purity; 0.5 mL; test site semi-occluded for 4 hr.	Slight dermal irritation; resolved by 48 hr.	
Skin sensitization Hartley/Dunkin Guinea Pig	96-98% Buchler method	Not a skin sensitizer	
Subchronic Toxicity Studies			
29/30-day dietary toxicity F-344 Rat 5/sex/group	96.4% purity 0, 50, 100, 500, 10000, 20000 ppm (0, 5.1/5.7, 10.4/11.6, 51.9/57.6, 1036/1134 and 2008/2193 mg/kg bw/day (♂/♀))	51.9/57.6 mg/kg bw/day (♂/♀)	> 1036/1134 mg/kg bw/day: ↓ PChE, ↓ EChE (♂) and "only slightly decreased in ♀", periportal hepatocyte hypertrophy; ↑ relative kidney weights (♂); ↓ BChE, ↑ relative/absolute liver weights (♀) 2008/2193 mg/kg bw/day: ↓ BChE, ↓ body weight gain; ↑ relative/absolute liver weights (♂); ↑ relative kidney weights (♀)
90-day dietary toxicity F-344 Rat 10/sex/group	96.4% purity 0, 100, 500, 5000, 10000, 20000 ppm (0, 6.6/7.9, 34.4/39.3, 340/384, 680/784 and 1190/1597 mg/kg bw/day (♂/♀))	34.4/39.3 mg/kg bw/day (♂/♀)	> 7.9 mg/kg bw/day: ↓ EChE (♀) > 34.4 mg/kg bw/day: ↓ EChE (♂) > 340/384 mg/kg bw/day: ↓ PChE, ↓ MCH, ↑ relative kidney weights; ↓ MCV, ↓ AP, ↑ relative/absolute liver weights, chronic nephropathy (♂); periportal hepatocyte hypertrophy (♀) > 680/784 mg/kg bw/day: ↓ BChE; ↓ HB, ↓ HCT, ↑ absolute kidney weights, periportal hepatocyte hypertrophy (♂); ↓ MCV, ↓ GGT, ↓ AST 1190/1597 mg/kg bw/day: ↓ weight gain, ↑ food consumption after week 1, anogenital staining; 1/10 deaths, ↓ GGT (♂); ↓ AP, ↑ relative/absolute liver weights, ↑ absolute kidney weights (♀)
90-day inhalation toxicity Sprague-Dawley Rat 15/sex/group 6h/day, 5days/wk; (whole body exposure)	96.4% purity 0, 0.1, 0.45 or 2.01 mg/L;	LOAEL: 0.1 mg/L	> 0.1 mg/L (25.8 mg/kg bw/day): ↑ clinical signs, slight to moderate histopathologic lesions of the nasal cavity (degeneration, hyperplasia of olfactory epithelium) and larynx (epithelial hyperplasia, squamous keratinization) > 0.45 mg/L (115 mg/kg bw/day): ↓ EChE; ↓ PChE, slight ↑ liver and kidney weights, slight ↑ cholesterol (♀) 2.01 mg/L (512 mg/kg bw/day): ↓ BChE, ↑ cholesterol, ↑ liver, kidney, lung weights. Note: histopathological findings in nasal and laryngeal mucosa also observed at lowest dose tested, 0.56 mg/L, in a 2-week whole-body inhalation range-finding study in rat.
21-day dermal toxicity N/ZW Rabbit 5-6/sex/group (6h/day, 5days/wk) (1989)	94% purity 0, 50, 300, 1000 mg/kg bw/day ncal		> 300 mg/kg bw/day: ↓ EChE; ↓ PChE, ↓ BChE (♀) 1000 mg/kg bw/day: ↓ PChE, ↓ BChE (♂), possible treatment-related mortality in 1 ♂. Study is considered supplemental

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
21-day dermal study NZW Rabbit 10/sex/group (2006)	96% purity 0, 75, 100, 150 or 500 mg/kg bw/day neat	sexes combined: EChE BMDL20- 107 BChE BMDL10- 180	> 75 mg/kg bw/day: slight to mild dermal irritation; ↓EChE(♂) > 150 mg/kg bw/day: ↓EChE(♀) 500 mg/kg bw/day: ↓BChE, ↓PChE
28-day oral toxicity (capsule) Beagle Dog 3/sex/group	92.4% purity 0, 125, 250, 500 mg/kg bw/day (ChE measured pretest, days 15,28)	LOAEL - 125 mg/kg bw/day	> 125 mg/kg bw/day: ↓ PChE, ↓EChE at study termination, diarrhoea > 250 mg/kg bw/day: ↓ PChE at day 15, marginal ↓ weight gain 500 mg/kg bw/day: ↓EChE by day 15, anorexia, ↓ food consumption, ↓ serum albumin, sodium, BUN, creatinine, ↓BWG; 1 death (♂); ↓uterine and ovarian weights (♀) BChE not measured
52-week oral study (capsule) Beagle Dog 6/sex/group	95% purity 0, 62.5, 125, 250 mg/kg bw/day; (ChE measured at 6, 13, 24, 52 wks)	LOAEL - 62.5 mg/kg bw/day	> 62.5 mg/kg bw/day: ↓ PChE and EChE at all time intervals, ↓ platelet counts, ↓ creatinine, ↓ ALT, ↓ absolute/relative liver and kidney weights; ↓BUN, ↓thyroid/parathyroid weight (♂) > 125mg/kg bw/day: red/white foci in stomach; ↓ RBC, ↓Hct, ↓BUN (♀) 250 mg/kg bw/day: ↓ cerebellar BChE (cerebrum BChE not affected), ↓Hb, ↓MCV, ↓MCH, ↓serum albumin, ↓total protein, ↓ calcium, ↓LDH; ↓RBC, ↓Hct, ↓AP (♂); ↓thyroid/parathyroid weight (♀)
Neurotoxicity Studies			
Acute delayed neurotoxicity (gavage) White Leghorn Hen 12/group	93.6% purity 1008 mg/kg bw (1.3 x oral LD ₅₀ of 775 mg/kg) with atropine protection; followed 21 days later with single injected dose of 853 mg/kg bw with protection		39/60 hens died by day 15. Of the survivors that were re-dosed on day 21, 7/21 died by day 28. 14 survived to study termination. Reversible moderate/severe ataxia, paralysis of legs and wings and inability to stand, lethargy, anorexia reported to day 4 and, after re-dosing, to day 25. No evidence of delayed type neuropathology. NTE (neurotoxic esterase) not measured
Acute neurotoxicity oral (gavage) Sprague Dawley Rat 27/sex/group	96.4% purity 0, 500, 1000, 2000 mg/kg bw	500 mg/kg bw	> 500 mg/kg bw: ↓PChE (♀) 1000 mg/kg bw: ↓EChE in ♀ (but not statistically significant); ↑salivation on day 0 2000 mg/kg bw (limit dose): ↓motor activity; clinical signs at the peak time of effect on day 1, ↓EChE in ♀ (♂ at day 7), ↓rotorod performance on day 14; lumbar dorsal root axonal degeneration, tibial nerve pathology (♂); ↑salivation on day 7, crusty deposits on mouth on day 14 (♀) Poor dose response. BChE and PChE (♂) was not affected Neuropathological effects considered equivocal

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
Acute Comparative Cholinesterase Assay, Oral (gavage) PND 11 Sprague-Dawley Rat 12/sex/group	malathion 96% purity 0, 10, 25, 50, 100, or 150 mg/kg bw sacrifice @60 min malaoxon 97.7% purity 0, 1, 3.5, 7, 10, or 12.5 mg/kg bw sacrifice @60min	malathion EChE BMIDL.20: 23 BChE BMIDL.10: 35 malaoxon malaoxon EChE BMIDL.20: 0.84 BChE BMIDL.10: 3.0	malathion ≥ 25 mg/kg bw/day: ↓ EChE (♀) ≥ 50 mg/kg bw/day: ↓ BChE, ↓ EChE (♂) ≥ 100 mg/kg bw/day: body tremors; ↓ BChE (-42%, s.s.) (♀) 150 mg/kg bw/day: body jerks (♀) malaoxon ≥ 3.5 mg/kg bw: ↓ EChE, ↓ BChE ≥ 10 mg/kg bw: body tremors
Acute time to peak effect, oral (gavage) PND 11 Sprague-Dawley Rat 8/sex/time point	malathion 96% purity 150 mg/kg bw sacrifice @ 10, 30, 60, 90, 240 minutes malaoxon 97.7% purity 12.5 mg/kg bw sacrifice @ 10, 30, 60, 90, 240 minutes		malathion time to peak: EChE ♂/♀: 60 minutes BChE ♂/♀: 60 minutes Clinical symptoms included body tremors, head tremors, body jerks. malaoxon time to peak: EChE ♂/♀: 60 minutes BChE ♂: 60 minutes BChE ♀: 90 minutes No clinical symptoms. Study is considered supplemental
Acute time to peak effect, oral (gavage) PND 11 Sprague-Dawley Rat 8/sex/time point	96% purity 150 mg/kg bw Termination at 30-360 minutes following dosing		Peak EChE at earliest time point of 30min. (Not clearly established) Peak BChE at 60min. No sex related differences. Study is considered supplemental
Range Finding 10-Day ChE for Comparative Malathion: Malaoxon Study, Oral (Gavage) PND 11 Sprague-Dawley Rat 5/sex/group	Malathion 96% purity 0, 5, 15 or 50 mg/kg bw/day Malaoxon 97.7% purity 0, 0.05, 0.1 or 1 mg/kg bw/day Animals dosed PND11-21		Malathion There were no treatment related effects on clinical signs, body weight or BChE inhibition. 50 mg/kg bw/day: ↓ EChE Malaoxon There were no treatment related effects on clinical signs or body weight were observed. 1 mg/kg bw/day: ↓ EChE, slight ↓ BChE (♀) Study is considered supplemental

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
10-Day Time to Peak Effect for ChE inhibition Comparative Malathion:Malaoxon Study, Oral (gavage)	Malathion 96% purity 150 mg/kg bw/day		Malathion Time to Peak effect for: EChE: 120 min. (♂), 180 min. (♀) BChE: 120 min. (♂/♀)
PND 11 Sprague-Dawley Rat 5/sex/group	Malaoxon 97.7% purity 4 mg/kg bw/day Animals dosed PND11-21		Whole body tremors, decreased motor activity, prostration, soft or liquid feces, coldness to the touch, impaired righting reflex and dehydration; ↓BW (♂) Malaoxon: Time to Peak effect for: EChE: 90 min. (♂), 120 min. (♀) BChE: Not achieved (no time-response relationship observed) No clinical signs or BW effects. Study is considered supplemental.
10-Day Cholinesterase Study, Oral (gavage)	Malathion 96% purity		No clinical signs or BW effects. ≥ 50 mg/kg bw: ↓EChE (♂) ≥ 150 mg/kg bw: ↓EChE(♀) 450 mg/kg bw: ↓BChE(♂) Study is considered supplemental.
PND 11 Sprague-Dawley Rat 6-7/sex/group	150 mg/kg bw/day for PND11-20, then acute dose of 50, 150 or 450 mg/kg bw		
10-Day Repeat Dose Comparative Toxicity of Malathion: Malaoxon, Oral (gavage)	Malathion 96% purity 0, 5, 25, 50 or 150 mg/kg bw/day	combined sexes Malathion EChE BMDL20: 19 mg/kg bw/day	Malathion No effects on BW or brain wt. ≥ 50 mg/kg bw/day: ↓EChE 150 mg/kg bw/day: tremors, ↓BChE; ↓motor activity (♂)
PND 11 Sprague-Dawley Rat 12 sex/group	Malaoxon 97.7% Purity 0, 0.1, 1, 2.5 or 4 mg/kg bw/day Animals dosed PND11-21	BChE BMDL10: 67 mg/kg bw/day Malaoxon EChE BMDL20: 1.0 mg/kg bw/day BChE BMDL10: N/A	Malaoxon No effects on clinical signs, BW, brain wt or BChE ≥ 2.5 mg/kg bw/day: ↓EChE
90-day dietary neurotoxicity Sprague Dawley rat 25/sex/group	96.4% purity 0, 50, 5000, 20000 ppm (= 0, 4/4, 352/395 and 1486/1575 mg/kg bw/day in ♂/♀)	4 mg/kg bw/day	≥ 352/395 mg/kg bw/day: ↓PChE, ↓EChE; ↓BChE (♀) 1486/1575 mg/kg bw/day: cholinergic signs and ↓weight gain, ↓forelimb grip strength; ↓BChE, sciatic nerve demyelination, lumbar dorsal root pathology, peroneal nerve pathology (♂) Neuropathology considered equivocal in nature.

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
Developmental neurotoxicity study (range-finding) Sprague-Dawley Rat 15/group/Phase	96.0% purity Phase 1 0, 7.5, 750 or 1250/1000 mg/kg bw/day in corn oil by gavage 1. Dams -from GD6 to PND 10 (10 ♀) or GD 6-20 (5 ♀); dams killed 3 hrs after dosing on GD 20. 2. Pups (2/sex/litter/dose group) treated PND 11-21 and killed 2 hrs after dosing on PND 21 for ChE determination. 3. Pups (2/sex/litter/dose group) treated PND 11-21 at 200 or 450 mg/kg bw/day. Phase 2 0, 3.5, 75 or 150 mg/kg bw/day in corn oil by gavage 1. Dams - from GD6 to PND 10 (10 ♀) or GD 6-20 (5 ♀) dams killed 3 hrs after dosing on GD 20. 2. Pups (2/sex/litter/dose group) treated PND 11-21 and killed 2 hrs after dosing on PND 21 for ChE determination. 3. Pups (2/sex/litter/dose group) treated PND 11-21 at 200 or 450 mg/kg bw/day.		Dams ≥ 75 mg/kg bw/day: post-dosing salivation, ↓ PChE, ↓ EChE ≥ 750 mg/kg bw/day: ↓ BChE, severe clinical signs (tremors, hypoactivity, prostrate posture, bulging eyes, abnormal respiration, abnormal gait), ↓ BWG, ↓ FC 1250/1000 mg/kg bw/day: mortalities Fetuses ≥ 750 mg/kg bw/day: ↓ EChE 1250/1000 mg/kg bw/day: ↓ BChE (♀) Pups ≥ 7.5 mg/kg bw/day: ↓ EChE (PND 21) ≥ 75 mg/kg bw/day: ↓ BChE (PND 21) ≥ 150 mg/kg bw/day: ↓ PChE (PND 21) ≥ 200 mg/kg bw/day: pups only dosed for 3 days due to severe clinical signs (body tremors, moribundity) - pups terminated before weaning due to excessive toxicity. Results from this study were used to select doses in the definitive DNT study. Highest dose was set at 150 mg/kg bw/day based upon the severity of the clinical signs noted at 200 mg/kg bw/day in the directly-dosed pups. There were no reproductive effects noted. No effects on brain weights of PND 21 pups.
Developmental neurotoxicity study Sprague-Dawley Rat 24 parental ♀/group	96.0% purity 0, 5, 50 or 150 mg/kg bw/day in corn oil by gavage from GD6 to PND10 (dams) and from PND 11-21 (pups)	Adult: 50 mg/kg bw/day Pups: 5 mg/kg bw/day	Adult ♀ 150 mg/kg bw: post-dosing salivation Pups ≥ 50 mg/kg bw/day: ↓ flattened gait (PND 60 ♂); ↓ motor activity (PND 17/22 ♀) 150 mg/kg bw: clinical signs of tremors, hypoactivity, prostrate posture, partially closed eyelids, abnormal gait (PND 17/18 ♂/♀), delayed surface righting reflex (PND 11 ♀)

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects																																	
Comparative ChE Study adults and juvenile Sprague-Dawley Rat	96.0% purity <u>Acute exposure</u> (by gavage) 0, 5, 50, 150 or 450 mg/kg bw 1. adults (8/sex/group) treated for 1 day 2. PND 11 pups (8/sex/group) treated for 1 day <u>Repeated exposure</u> (by gavage) 0, 5, 50 or 150 mg/kg bw/day 1. adult (8/sex/group) treated for 11 days 2. 19 adult ♀ (9♀ treated GD6-20, 10♀ treated GD1-10, 3. pups (8/sex/group) treated for 11 days (PND11-21) 4. pups (2/sex/litter/group) sacrificed 4 hours after dosing of the dam at PND 4	<u>Acute exposure</u> Adult: 150 mg/kg bw Pups PND 11: LOAEL: 5 mg/kg bw <u>Repeated exposure</u> Adult: 5 mg/kg bw/day Pregnant ♀ GD20: 5 mg/kg bw/day Fetuses GD20: 50 mg/kg bw/day Pups: PND 4: >150 mg/kg bw/day PND 21: LOAEL: 5 mg/kg bw/day	<u>Acute exposure</u> Adult: 450 mg/kg bw: 1 EChE (25%♂, 17%♀) Pups PND 11: ≥5 mg/kg bw: 1 EChE (16%♂) ≥50 mg/kg bw/day: 1 PChE, 1 EChE (25%♂, 23%♀), 1 BChE (10%♀) ≥150 mg/kg bw: 1 PChE, 1 EChE (48%♂, 55%♀), 1 BChE (44%♂, 48%♀) 450 mg/kg bw: 1 PChE, 1 EChE (♂/♀), 1 BChE (84%♂, 81%♀); tremors <u>Repeated exposure</u> Adult: ≥50 mg/kg bw/day: 1 EChE (20%♂, 20%♀) 150 mg/kg bw/day: 1 EChE (43%♂, 48%♀) Pregnant ♀ GD20: ≥50 mg/kg bw/day: 1 EChE (19%) 150 mg/kg bw/day: 1 EChE (51%), post-dose salivation Fetuses GD20: ≥50 mg/kg bw/day: 1 EChE (11%) 150 mg/kg bw/day: 1 EChE (19%), Pups: PND 4 : No effects PND 21: ≥5 mg/kg bw/day: 1 EChE (17%♂, 15%♀) ≥50 mg/kg bw/day: 1 EChE (39%♂, 34%♀) 150 mg/kg bw/day: 1 EChE (67%♂, 68%♀), 1 BChE (16% ♂/♀) At similar dose levels PND 11 and PND 21 pups are more sensitive than are adult animals to the effects of malathion on cholinesterase enzyme inhibition.																																	
<table><tr><th>Endpoint (sexes combined)</th><th>BMD₁₀ (BMDL₁₀) mg/kg/day</th><th>BMD₂₀ (BMDL₂₀) mg/kg/day</th></tr><tr><td colspan="3">Acute Exposure</td></tr><tr><td>Day 1 Adults EChE</td><td>113.2 (62.1)</td><td>NA (NA)</td></tr><tr><td>PND 11 EChE</td><td>17.6 (15.1)</td><td>31.1 (27.1)</td></tr><tr><td colspan="3">Repeat Dose Exposure</td></tr><tr><td>GD 20 Dams EChE</td><td>21.5 (19.5)</td><td>45.4 (41.3)</td></tr><tr><td>GD 20 Fetuses EChE</td><td>78.4 (54.4)</td><td>166.0 (115.1)</td></tr><tr><td>Day 11 Adult EChE</td><td>25.8 (23.3)</td><td>54.7 (49.4)</td></tr><tr><td>PND 4 Male EChE</td><td>135.0 (64.0)</td><td>286.0 (135.5)</td></tr><tr><td>PND 4 Female EChE</td><td colspan="2">No dose-response</td></tr><tr><td>PND 21 EChE</td><td>14.7 (12.8)</td><td>31.1 (27.1)</td></tr></table>				Endpoint (sexes combined)	BMD ₁₀ (BMDL ₁₀) mg/kg/day	BMD ₂₀ (BMDL ₂₀) mg/kg/day	Acute Exposure			Day 1 Adults EChE	113.2 (62.1)	NA (NA)	PND 11 EChE	17.6 (15.1)	31.1 (27.1)	Repeat Dose Exposure			GD 20 Dams EChE	21.5 (19.5)	45.4 (41.3)	GD 20 Fetuses EChE	78.4 (54.4)	166.0 (115.1)	Day 11 Adult EChE	25.8 (23.3)	54.7 (49.4)	PND 4 Male EChE	135.0 (64.0)	286.0 (135.5)	PND 4 Female EChE	No dose-response		PND 21 EChE	14.7 (12.8)	31.1 (27.1)
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Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
32-day oral toxicity human 10 ♂ adults	Purity not stated; Phase I - (5 subjects) 8 mg/day for 32 days , followed by 3 wk interval then Phase II- 16 mg/day for 47 days. Phase III- (5 new subjects) 24 mg/day for 56 days		@ 8 mg/day for 32 days: no effects observed. @ 16 mg/day (~0.27 mg/kg bw/day) for 47 days: no effects observed. @ 24 mg/day (~0.41 mg/kg bw/day) for 56 days : 1 PChE. 2 weeks after start of dosing, 1 EChE 3 weeks after cessation of dosing. No clinical signs reported at any dose level. Study is considered supplemental
Chronic Toxicity/Oncogenicity Studies			
18-month dietary carcinogenicity B6C3F1 mouse 65/sex/group 12 month interim kill 10/sex/group	96.4% purity 0, 100, 800, 8000, 16000 ppm (- 0, 17.4/20.8 , 143/167, 1476/1707 and 2978/3448 mg/kg bw/day in ♂/♀)	143/20.8 mg/kg bw/day (♂/♀) (chronic toxicity)	Chronic Toxicity ≥ 143/167 mg/kg bw/day: 1 PChE and 1 EChE; nasal lesions (olfactory atrophy and degeneration, ↑ glandular secretions, suppurative exudate)(♀) ≥ 1476/1707 mg/kg bw/day: ↓ body weight , ↓ food consumption, ↑ hepatocellular hypertrophy, nodules; ↑ liver weight, nasal lesions (olfactory atrophy and degeneration, ↑ glandular secretions, suppurative exudate) (♂) 2978/3448 mg/kg bw/day: 1 BChE, ↑ incidence hepatic foci; ↑ liver weight (♀) Carcinogenicity Treatment-related increased incidence of liver tumors (hepatocellular adenomas /carcinomas) in ♂/♀ mice at doses (8000 and 16000 ppm) which exceeded the Limit Dose of 1000 mg/kg bw/day.
24-month chronic toxicity/ carcinogenicity F-344 Rat 90/sex/group (15/sex/group for interim kill at 12 months and 10/sex/group at 3 and 6 months)	97.1% purity 0, 50, 100/50 (reduced day 113), 500, 6000, 12000 ppm (- 0, 2.4/3.0, 26/32, 327/386 and 677/817 mg/kg bw/day in ♂/♀)	3.0mg/kg bw/day (chronic toxicity)	Chronic Toxicity ≥ 26/32 mg/kg bw/day: 1 PChE; chronic nephropathy (♀) ≥ 327/386 mg/kg bw/day: 1 EChE, 1 BChE, ↓ weight gain, ↓ food consumption, effects on erythrocyte and clinical chemistry parameters, ↑ abs. liver wt., ↑ kidney weight, lesions of nasal mucosa (degeneration and hyperplasia of olfactory epithelium), nasopharynx irritation (inflammation and hyperplasia of respiratory epithelium, ♀ > ♂), gastric histopathology; ↑ mortality (20th month), ↑ rel. liver wt., ↑ spleen weight, chronic nephropathy (♂) 677/817 mg/kg bw/day: ↑ mortality seen in ♂ (14 month, all ♂ died by 94 weeks) deaths resulting from nephropathy and mononuclear cell leukemia (MCL); ↑ rel. liver wt., anogenital staining (♀) Carcinogenicity 817 mg/kg bw/day: Treatment-related ↑ incidence of liver adenomas in ♀ Solitary nasal and oral tumors at 6000 and 12000 ppm (the oral [♀ at 6000 and 12,000 ppm] and nasal tumors [♀ at 6000 and 12,000 ppm and ♂ at 12,000 ppm] all relatively rare tumors in F344 rat) could not be distinguished as either treatment-related or of random occurrence.

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
Reproductive and Developmental Toxicity Studies			
Two-generation (2 litters/gen) dietary reproductive toxicity Sprague-Dawley Rat 25/sex/group	94% purity 0, 550, 1700, 5000, 7500 ppm (- 0, 43/51, 131/153, 394/451, 612/703 mg/kg bw/day in ♂/♀)	Parental: 394/451 mg/kg bw/day Reproductive: 612/703 mg/kg bw/day Offspring: 131/153 mg/kg bw/day	Parental toxicity: 612/703 mg/kg bw/day: ↓ weight gain in F1 during pre-mating; marginal ↓ weight gain in F0 during gestation and lactation (♀). Reproductive toxicity: 612/703 mg/kg bw/day: No effect on reproductive parameters. Offspring toxicity: ≥ 394/451 mg/kg bw/day: ↓ pup weight in F1A and F2B at PND 21 612/703 mg/kg bw/day: ↓ pup weight in all F1/2 litters at PND 21 Note: cholinesterase activity not measured.
Developmental toxicity (gavage) Sprague-Dawley Rat 24-25 ♀/group	94% purity 0, 200, 400, 800 mg/kg bw/day on gestation days 6-15	Maternal: 400 mg/kg bw/day Developmental: 400 mg/kg bw/day	Maternal toxicity: 800 mg/kg bw/day: urine -staining of abdominal fur, chromodacryorrhea and chromorhinorrhea; ↓ weight gain, ↓ food consumption during dosing; Developmental toxicity: 800 mg/kg bw/day: ↓ numbers of dams with resorptions Note: cholinesterase activity was not measured.
Developmental toxicity (gavage), NZW Rabbit 5 ♀/group (range-finding)	92.4% purity; 0, 25, 50 100, 200, 400 mg/kg on gestation days 6- 18		Maternal toxicity: ≥ 200 mg/kg bw/day: cholinergic signs of toxicity (tremors, ↑ activity, excess salivation), mortality No developmental toxicity observed. Note: cholinesterase activity was not measured. Study is considered supplemental
Developmental toxicity (gavage), NZW Rabbit 20 ♀/group	92.4% purity 0, 25, 50, 100 mg/kg bw/day on gestation days 6-18	Maternal: 25 mg/kg bw/day Developmental: 25 mg/kg bw/day	Maternal toxicity: ≥ 50 mg/kg bw/day: ↓ weight gain during dosing 100 mg/kg bw/day: anorexia, soft stools Developmental toxicity: ≥ 50 mg/kg bw/day: ↓ number of dams with resorptions, ↓ resorptions per doe Note: cholinesterase activity was not measured.
Immunotoxicity Studies			
Acute and 8-day oral (gavage) Immunotoxicity C57Bl/6 Mouse 10 ♂/ group	95% Purity 0 or 720 mg/kg bw acute (IgM assay) 0 or 240 mg/kg bw/day repeat for 4 doses (IgG assay) Doses 2 days after immunization SRBC		IgM response suppressed, but not IgG Study is considered supplemental

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
28-day oral (gavage) Immunotoxicity, SJL/J Mouse 16-17♀/group	50% Purity (Malathion 500EC, EP) 0, 0.018, 7.2, 180 mg/kg bw/day on alternate days Mice sacrificed 24h after last dose vehicle: corn oil Immunized (on day 25) with Sheep Red Blood Cells (SRBC)		No effects on food or water consumption, body weight, BChE, spleen or brain weights Increased IgM (150% of Control) at all doses. 180 mg/kg bw/day: slight ↑ kidney wt., ↑ liver wt. No mitogenic responses to Lipopolysaccharide (B-lymphocyte specific) or Concanavalin A (T-lymphocyte specific) PChE, EChE not measured. Study is considered supplemental
Subchronic oral Immunotoxicity Hissar Mouse for 3-12 weeks (feed) Wistar Rat for 8-22 weeks (feed) NZW Rabbit for 21 weeks (gavage) n = 10-12 ♂/ group + matched controls	>99% Purity 0, 20, 50 or 100 ppm for mice and rats 0.5 or 2.5 mg/kg bw/day for rabbits Mice and rats were Immunized with SRBC and tetanus toxoid or ovalbumin 20 days before termination of treatment, Rabbits immunized with ovalbumin measurements: i) immunoglobulin levels ii) antibody titre iii) plaque forming assay iv) leucocyte migration inhibition (IMI) test weeks 4,6,7,8,12,15,19,21 v) macrophage migration inhibition (MMI) test		Mice: No effect on BW, immunoglobulins or thymus wt. 50 ppm: ↓ rel. spleen wt., (w/ SRBC) ↓ MMI, ↓ secondary antibody response to SRBC, ↓ Plaque forming cell response 100 ppm: ↑ rel. liver wt., ↓ IMI Rats: No effect on BW, IgM, thymus or liver wt. > 50 ppm: ↓ rel. spleen wt. (w/ ovalbumin and tetanus), ↓ MMI, ↓ IMI, ↓ antibody titre to both tetanus and ovalbumin 100 ppm: ↓ IgG after tetanus toxoid or ovalbumin immunization, ↓ IMI Rabbits No effect on BW, organ weights or immunoglobulin levels 2.5 mg/kg bw/day: ↓ serum antibody response to ovalbumin, ↓ IMI Study considered supplemental.
Acute oral (gavage) Immunotoxicity C57Bl/6 Mouse 2-3 ♀/time point/dose also RBL-1 (rat basophilic cell line) <i>in vitro</i> - reported only in appendix 2 (mechanistic)	>99% Purity vehicle: corn oil <i>in vivo</i> assay: peritoneal cells harvested following malathion treatment for exposure to PMA		Acute <i>in vivo</i> malathion exposure increased hydrogen peroxide production / respiratory burst An increase in mast cell degranulation was observed in treated cells. Study is considered supplemental.
Acute Oral (gavage) Immunotoxicity C57Bl/6 Mouse ♀	>99% Purity Acute: 0 or 715 mg/kg bw		715 mg/kg bw: ↑ stimulation of splenocytes by stimulus from ConA and LPS mitogens, ↑ respiratory burst of peritoneal cells Study is considered supplemental.
A series of supplemental <i>in vitro</i> studies link malathion with several cellular immunotoxicity mechanisms including increased respiratory burst of macrophages (possibly through increased degranulation of mast cells) as well as decreased nitrite production and TNF-α production under various test scenarios.			

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
Genotoxicity Studies			
Gene mutation: <i>Salmonella typhimurium</i> / <i>Escherichia coli</i>	92.8% purity TA 1535, TA 100, TA 1537, TA 98. WP-2 uvrA ⁺ ± S9 activation	Negative	
Gene mutation: <i>Salmonella typhimurium</i> / <i>Escherichia coli</i>	95.4% purity ± S9 activation	Negative	
<i>In vitro</i> Bacterial direct DNA damage tests with <i>Escherichia coli</i> W3110/p 3478 and <i>Bacillus subtilis</i> H17/m45	1000 µg/plate	Negative	
<i>In vitro</i> Mitotic Recombination assay with <i>S. cerevisiae</i> D3	50 mg/mL	Negative	
<i>In vitro</i> cytogenetic assay measuring SCE Chinese hamster 79 cells	94% purity 10-80 µg/mL	Positive at high dose level only (>40 µg/mL). Potent inducer of cell cycle delay. Cytotoxicity was not determined.	
<i>In vitro</i> cytogenetic assay measuring SCE in Chinese hamster ovary cells	99% purity 0.03, 0.1, 0.3, and 1.0 mM	Positive for the induction of SCEs at high doses only (>0.3 mM).	
<i>In vitro</i> cytogenetic assay measuring SCE/chromosome aberrations in human peripheral leukocytes	0.02-20 µg/mL	Positive for the induction of SCEs and chromosome aberrations	
<i>In vitro</i> cytogenetic assay measuring SCE in human lymphocytes	98% purity 5, 20, 40 or 50 µg/mL for 4 or 24 hr	Positive for the induction of SCEs and chromosome aberrations (gaps, breaks, gaps plus breaks) at >40 µg/mL. Significant cytotoxicity noted at highest dose of 50 µg/mL.	
<i>In vitro</i> cytogenetic assay measuring SCE in human fetal lung fibroblasts	99% purity 0, 2.5, 5, 10, 20 or 40 µg/mL	Positive for the induction of SCEs > 20 µg/mL.	
Unscheduled DNA Synthesis primary rat hepatocytes	94% purity 0, 0.4, 0.8 or 1.6 mL/kg (equivalent to 0, 0.5, 1.0, and 2.0 g/kg)	Negative	
Unscheduled DNA Synthesis human fibroblasts WI-38	92-97% purity 10 ⁻⁷ - 10 ⁻³ ± S9 activation	Negative	
Dominant lethal study - ♂ ICR/SIM mice	92-97% purity 1250, 2500 and 5000 mg/kg bw/day in diet	Negative	
Dominant lethal/Chromosome aberration study ♂Q mice	99% purity 300 mg/kg bw ip injection	Negative	

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
Chromosome Aberration: <i>in vivo</i> bone marrow and spermatogonia cytogenetic assays, mice Swiss Webster	0, 500, 1000 or 2000 mg/kg bw dermal, also repeated dermal	Negative in <i>in vivo</i> bone marrow and spermatogonia cytogenetic assays	
Investigation of dose relationships and the induction of Chromosome Aberration: <i>in vivo</i> bone marrow assays, mice BALB/c	95.5% purity 0, 115, 230, 460 mg/kg bw	Significant increases in abnormal metaphases, gaps, breaks and chromatid exchanges at all sample times at 460 mg/kg bw.	
Chromosome Aberration: <i>in vivo</i> bone marrow assay, rats Sprague-Dawley	94% purity single oral gavage of 500- 2000 mg/kg	Negative	
Malaoxon Toxicity Studies (cholinesterase-inhibiting metabolite and impurity of malathion)			
Acute oral toxicity Swiss mouse		LD50 – 215 mg/kg bw (♀)	
Acute oral toxicity Wistar rat		LD50 – 142–175 mg/kg bw (♂)	
Acute time to peak effect, oral (gavage) Malaoxon PND 11 Sprague-Dawley Rat 8/sex/time point	97.7% Purity 7.7 mg/kg bw Termination at 20-240 minutes following dosing		Peak EChE and BChE at the earliest time point of 20 minutes. No sex related differences. Peak BChE, EChE inhibition not established. Study is considered supplemental.
Acute range-finding study, oral (gavage) Malaoxon PND 11 Sprague-Dawley Rat 5/sex/dose	97.7% Purity Phase 1: 0, 10, 20 or 30 mg/kg bw Phase 2: 0, 1, 3 or 5 mg/kg bw Phase 3: 1/0.1, 1.5/0.5 or 3/1 mg/kg bw (♂/♀) Terminated 20-30 min following dosing		>0.5 mg/kg bw: 1 EChE (♀) >1.0 mg/kg bw: 1 BChE (♀) >1.5 mg/kg bw: 1 EChE (♂) >3.0 mg/kg bw: 1 BChE (♂) >20 mg/kg bw: subdued behaviour, body/head tremors, cold to touch, abnormal skin colour, death Study is considered supplemental.
Refer to the neurotoxicity section of malathion for studies investigating the cholinesterase inhibiting effects of BOTH malathion and malaoxon.			
103-week dietary carcinogenicity study B6C3F1 Mouse 50/sex/dose	>95% purity 0, 500, 1000 ppm		No evidence of carcinogenicity.

Study/Species/ # of animals per group	Purity of Test Material / Dose Levels	NOAEL (mg/kg bw/day)	Results/Effects
104-105 week dietary chronic toxicity/ carcinogenicity F344 Rat 85/sex/group	96.4% purity 0, 20, 1000, 2000 ppm (= 0, 1, 57/68, and 114/141 mg/kg bw/day in ♂/♀)	1 mg/kg bw/day	1 mg/kg bw/day: 1 EChE after 6 months ≥ 57/68 mg/kg bw/day: 1 PChE, 1 EChE, 1 BChE; 1 incidences of mineral deposits in the stomach muscularis (♂); 1 mortality, 1 incidence of foreign material/cellular debris in nasal cavity, nasal lumen inflammation, microscopic changes in the nasal epithelial tissue (hyperplasia), lung interstitium and tympanic cavity (♀) 114/141 mg/kg bw/day: 1 mortality, 1 body weight, 1 food consumption, yellow anogenital staining, 1 incidences of mineral deposits in the stomach muscularis; 1 incidence of foreign material/cellular debris in nasal cavity, nasal lumen inflammation, 1 liver weight, 1 kidney weight (12 mos), 1 adrenal weight (♂); 1 spleen weight (♀) No evidence of carcinogenicity.
<i>In vitro</i> cytogenetic assay measuring SCE in Chinese hamster ovary cells	96% purity 0.03, 0.1, 0.3, and 1.0 mM	Weakly Positive for the induction of SCEs and cell cycle delay at doses ≥ 0.1 mM.	
Gene mutation: <u>Salmonella typhimurium</u>	94.4% purity TA 97, TA 98, TA 100, TA 1535, TA 1537 10-10000 µg/plate ± S9 activation	Negative	
Gene mutation: <u>Salmonella typhimurium</u>		Negative	
Gene mutation mouse lymphoma cell assays (detects both chromosomal aberrations and point mutations)		Positive; -S9 activation; Lowest effective concentration (LEC) = 123.5 µg/mL.	
Gene mutation mouse lymphoma cell assays (detects both chromosomal aberrations and point mutations)	12.5-300 n L/mL. ± S9 activation	Positive; -S9 activation; LEC = 150 µg/mL.	
Isomalathion (impurity of malathion)			
Acute toxicity Lac:P rat 6 ♀/group	98% purity	LD50: 113 mg/kg bw	
Gene mutation: <u>Salmonella typhimurium</u>	TA 97, TA 98, TA 100 10-1000 µg/plate ± S9 activation	Negative	
<i>in vitro</i> Cholinesterase inhibiting assay Sprague-Dawley	Rate of acetylthiocholine hydrolysis monitored by spectrophotometer following addition of malathion and isomalathion to brain tissue	An increased inhibition (>1000x) of brain cholinesterase function was observed following administration of isomalathion compared to malathion. Study is considered supplemental	

Appendix IV Occupational Exposure Risk Estimates for Malathion

Table 1 Dermal and Inhalation MOEs for Mixing, Loading and Applying Malathion

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure $\mu\text{g/kg/day}$		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{c,d}	Inhalation ^e	
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
3: Empty Food Storage	Grain elevators, grain box cars	LP Handwand	EC, SN	1.67 g ai/m ²	557 m ²	1.25	0.6	19943	42954	13483
		Backpack	EC, SN	1.67 g ai/m ²	557 m ²	7.24	0.83	3455	31265	3101
	Granary box cars	LP Handwand	EC, SN	167 g ai/car	10 cars	2.25	1.08	11108	23926	7510
		Backpack	EC, SN	167 g ai/car	10 cars	12.99	1.48	1924	17414	1727
	Granary Bins (empty)	LP Handwand	EC, SN	1.67 g ai/m ²	370 m ²	0.83	0.4	30022	64664	20297
		Backpack	EC, SN	1.67 g ai/m ²	370 m ²	4.81	0.55	5201	47066	4668
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
5: Greenhouse Food Crops	Mushroom Beds	LP Handwand	EC	0.2 g ai/m ²	1600 m ²	0.43	0.21	6956	124862	4703
		Backpack	EC	0.2 g ai/m ²	1600 m ²	2.49	0.28	1205	90882	1082
	Greenhouse Lettuce	LP Handwand	EC	1375 g ai/ha	2 ha	3.71	1.78	809	14529	547
		Backpack	EC	1375 g ai/ha	2 ha	21.39	2.44	140	10575	126
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
6: Greenhouse Ornamentals	Ornamentals	LP Handwand	EC	0.0976 g ai/m ²	20000 m ²	2.63	1.26	1140	20469	771
		Backpack	EC	0.0976 g ai/m ²	20000 m ²	15.19	1.73	198	14899	177
		HP Handwand	EC	0.0976 g ai/m ²	20000 m ²	15.58	4.21	193	6127	152

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure $\mu\text{g/kg/day}$		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{c,4}	Inhalation ^e	
6: Greenhouse Ornamentals	Ornamentals	LP Handwand	EC	0.8	150 L	0.162	0.077	18551	332965	12541
		Backpack	EC	0.8	150 L	0.934	0.106	3213	242351	2885
		HIP Handwand	EC	0.8	3750 L	23.938	6.47	125	3987	99
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
8: Livestock for Feed	Dairy and beef cattle	Backrubber ^g	EC	20 g ai/L	200 L	0.292	0.091	85549	282188	65162
		LP Handwand	EC	10 g ai/L	150 L	2.022	0.969	12367	26637	8361
		Backpack	EC	10 g ai/L	150 L	11.67	1.331	2142	19388	1923
		HIP Handwand	EC	10 g ai/ L	3750 L	299.22	80.89	84	319	66
		Dust ^h	EC	2.4 g ai/animal	200 animals	0.364	0.385	68611	66948	33345
	Goat, Sheep	LP Handwand	EC	10 g ai/L	150 L	2.022	0.969	12367	26637	8361
		Backpack	EC	10 g ai/L	150 L	11.67	1.331	2142	19388	1923
		HIP Handwand	EC	10 g ai/L	3750 L	299.22	80.89	84	319	66
	Swine	LP Handwand	EC	21.5 g ai/ animal	200 animals/day	5.8	2.78	4314	9292	2917
		Backpack	EC	21.5 g ai/ animal	200 animals/day	33.45	3.82	747	6763	671
		HIP Handwand	EC	21.5 g ai/ animal	200 animals/day	34.31	9.28	729	2781	574
		Dust ^h	DU	1.2 g ai/animal	200 animals/day	0.182	0.193	137221	133897	66689
8: Livestock for Feed	Poultry	LP Handwand	EC	0.3 g ai/ bird	20,000 birds/day	8.22	3.94	3041	6550	2056
		Backpack	EC	0.3 g ai/ bird	20,000 birds/day	47.46	5.41	527	4768	473
		HIP Handwand	EC	0.3 g ai/ bird	20,000 birds/day	48.67	13.16	514	1961	404

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure $\mu\text{g/kg/day}$		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{a,d}	Inhalation ^c	
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
USC 12: Stored Food and Feed (Wheat, oats, corn, rice, rye and barley)	Application to grain by farmer	Dust ^b	DU	15 g ai/1000 kg of grain	40 tons/day	0.455	0.048	54889	535587	49639
		Dust ^b	DU	0.96 g ai/m ²	557 m ²	0.406	0.043	61589	600973	55699
		Backpack	EC, SN	30 g ai/1000 kg of grain	40 tons/day	9.34	1.07	2678	24235	2404
		Backpack	EC, SN	60.38 g ai/L	150 L	70.46	8.04	355	3211	318
		Backpack	EC, SN	3 g ai/m ²	557 m ²	13	1.482	1923	17404	1726
		I.P Handwand	EC, SN	30 g ai/1000 kg grain	40 tons/day	1.62	0.775	15459	33296	10451
		I.P Handwand	EC, SN	60.38 g ai/L	150 L	12.21	5.848	2048	4412	1385
		I.P Handwand	EC, SN	3 g ai/m ²	557 m ²	2.252	1.079	11101	23911	7505
	Application to grain in large holding facilities	Dust ^b	DU	15 g ai/1000 kg of grain	50000 tons/day	569.33	60.21	44	428	40
	Commercial ^f	EC, SN	30 g ai/1000 kg grain	50000 tons/day	109.59	34.29	228	753	174	
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
USC 13: Terrestrial Food Crops	Cereal crops, pasture and range, grasses or legumes being grown for hay, alfalfa, clover, canary grass, corn (grain, forage), sweet clover	ULV Ground	EC, SN, LI	1375 g ai/ha	1200 ha	1444	174.43	17	148	15
		Aerial Mixer/Loader	EC, SN, LI	1375 g ai/ha	400 ha	40.18	12.57	622	2052	474
		Aerial Applicator	EC, SN, LI	1375 g ai/ha	400 ha	8.431	0.55	2965	46909	2784
		Groundboom: Farmer	EC, SN, LI	1375 g ai/ha	100 ha	16.52	5.029	1513	5131	1160

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure µg/kg/day		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{c,d}	Inhalation ^e	
USC 13: Terrestrial Food Crops	Cereal crops, pasture and range, grasses or legumes being grown for hay, alfalfa, clover, canary grass, corn (grain, forage), sweet clover	Groundboom: Custom Applicator	EC, SN, I.I	1375 g ai/ha	300 ha	49.57	15.09	504	1710	387
Mid-Level PPE: Cotton coveralls over long pants, long sleeved shirts, and chemical-resistant gloves										
USC 13: Terrestrial Food Crops	Cereal crops, pasture and range, grasses or legumes being grown for hay, alfalfa, clover, canary grass, corn (grain, forage), sweet clover	ULV Ground	EC, SN, I.I	1375 g ai/ha	1200 ha	1227	174.43	20	148	18
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
USC 14: Terrestrial Food Crops	High Acreage Vegetables ^l	Groundboom: Farmer M/I/A	EC	1500 g ai/ha	100 ha	18.026	5.486	1387	4703	1063
		Groundboom: Custom Applicator M/I/A	EC	1500 g ai/ha	300 ha	54.077	16.457	462	1568	354
	Low Acreage Vegetables ^k	Groundboom: Farmer M/I/A	EC	1500 g ai/ha	30 ha	5.408	1.646	4623	15677	3544
		Groundboom: Custom Applicator M/I/A	EC	1500 g ai/ha	80 ha	14.42	4.389	1734	5879	1329

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure $\mu\text{g/kg/day}$		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{c,d}	Inhalation ^e	
Baseline PPE: Long pants, long sleeved shirts, and chemical-resistant gloves. Engineering control: Water soluble packaging (WSP)										
USC 14: Terrestrial Food Crops	High Acreage Vegetables ⁱ	Groundboom: Farmer M/L/A	WP WSP	1500 g ai/ha	100 ha	11.698	2.443	2137	10561	1768
USC 14: Terrestrial Food Crops	High Acreage Vegetables ⁱ	Groundboom: Custom Applicator M/L/A	WP WSP	1500 g ai/ha	300 ha	35.094	7.329	712	3520	589
	Low Acreage Vegetables ^k	Groundboom: Farmer M/L/A	WP WSP	1500 g ai/ha	30 ha	3.509	0.733	7124	35205	5893
		Groundboom: Farmer M/L/A	WP WSP	1500 g ai/ha	80 ha	9.358	1.954	2671	13202	2210
Maximum PPE: Chemical-resistant coveralls over long sleeves and long pants and chemical-resistant gloves (except for Aerial applicator: long pants, long sleeved shirt and chemical-resistant gloves)										
USC 14: Terrestrial Food Crops	ULV Applications (High Rate) ^j	ULV Aerial M/L	EC, SN	1375 g ai/ha	3000 ha	171.42	94.286	146	274	94
		ULV Aerial Applicator	EC, SN	1375 g ai/ha	3000 ha	63.23	4.125	395	6255	371
		ULV Groundboom	EC, SN	1375 g ai/ha	1200 ha	1183.1	174.429	21	148	18
	ULV Applications (Low Rate) ^m	ULV Aerial M/L	EC, SN	653 g ai/ha	3000 ha	81.41	44.78	307	576	198
		ULV Aerial Applicator	EC, SN	653 g ai/ha	3000 ha	30.029	1.959	833	13170	782
		ULV Groundboom	EC, SN	653 g ai/ha	1200 ha	561.864	82.838	44	311	39
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
USC 14: Terrestrial Food Crops	Fruit Trees ⁿ	Airblast	EC	3950 g ai/ha	16 ha	55.333	6.681	452	3862	403

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure µg/kg/day		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{c,d}	Inhalation ^e	
USC 14: Terrestrial Food Crops	Berries (High Rate) ^g	Groundboom: Farmer	EC	2753 g ai/ha	30 ha	9.93	3.02	2519	8542	1931
		Groundboom: Custom	EC	2753 g ai/ha	80 ha	26.47	8.05	945	3203	724
		Airblast	EC	2753 g ai/ha	16 ha	38.57	4.66	648	5541	578
		LP Handwand	EC, WP	2753 g ai/L	2 ha	7.42	3.56	3369	7257	2278
		Backpack	EC, WP	2753 g ai/L	2 ha	42.84	4.89	584	5282	524
	Berries (Low Rate) ^g	Groundboom: Farmer	EC	1023 g ai/ha	30 ha	3.688	1.122	6779	22987	5197
		Groundboom: Custom	EC	1023 g ai/ha	80 ha	9.835	2.993	2542	8620	1949
USC 14: Terrestrial Food Crops	Berries (Low Rate) ^g	Groundboom: Farmer	WP	1023 g ai/ha	30 ha	24.74	25.06	1010	1030	502
		Airblast	EC	1023 g ai/ha	16 ha	14.33	1.73	1745	14910	1557
		LP Handwand	EC, WP	1023 g ai/ha	2 ha	2.757	1.321	9067	19529	6130
		Backpack	EC, WP	1023 g ai/ha	2 ha	15.917	1.815	1571	14214	1410
Baseline PPE: Long pants, long sleeved shirts, and chemical-resistant gloves. Engineering control: Water soluble packaging (WSP)										
USC 14: Terrestrial Food Crops	Fruits ^a	Airblast	WP WSP	3950 g ai/ha	16 ha	52.666	5.399	475	4779	431
	Berries (High Rate) ^g	Groundboom: Farmer	WP WSP	2753 g ai/ha	30 ha	6.441	1.345	3881	19182	3211
USC 14: Terrestrial Food Crops	Berries (High Rate) ^g	Groundboom: Custom	WP WSP	2753 g ai/ha	80 ha	17.176	3.587	1456	7193	1204
		Airblast	WP WSP	2753 g ai/ha	16 ha	36.706	3.763	681	6856	618
	Berries (Low Rate) ^g	Groundboom: Custom	WP WSP	1023 g ai/ha	80 ha	6.382	1.333	3917	19357	3240

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure µg/kg/day		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{c,d}	Inhalation ^e	
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
USC 14: Terrestrial Food Crops	Grapes	Airblast	EC	1750 g ai/ha	16 ha	24.514	2.96	1020	8716	910
	Cranberry	Groundboom: Farmer	EC	2760 g ai/ha	30 ha	9.95	3.028	2513	8520	1926
		Groundboom: Custom	EC	2760 g ai/ha	80 ha	26.53	8.075	942	3195	722
		Chemigation	EC	2760 g ai/ha	140 ha	28.229	8.832	886	2921	675
		LP Handwand	EC	2760 g ai/ha	2 ha	7.439	3.564	3361	7238	2272
		Backpack	EC	2760 g ai/ha	2 ha	42.944	4.897	582	5269	523
	Corn (grain, forage)	Groundboom: Farmer	EC	1375 g ai/ha	80 ha	13.219	4.023	1891	6413	1450
		Groundboom: Custom	EC	1375 g ai/ha	140 ha	23.133	7.04	1081	3665	829
Maximum PPE: Chemical-resistant coveralls over long sleeves and long pants and chemical-resistant gloves										
USC 20: Structural	Flour mills, flour mill warehouses, feed mills	LP Handwand	EC	32.5 g ai/L	150 L	4.83	3.148	621	8196	376
		Backpack Sprayer	EC	32.5 g ai/L	150 L	14.119	4.32	212	5966	163
		HIP Handwand	EC	32.5 g ai/L	3750 L	318.116	262.902	9	98	5
	Dwelling Foundations	LP Handwand	EC	32.5 g ai/L	150 L	4.83	3.148	5176	8196	3134
		Backpack Sprayer	EC	32.5 g ai/L	150 L	14.119	4.325	1771	5966	1355
		HIP Handwand	EC	32.5 g ai/L	3750 L	318.116	262.9	79	98	43

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure $\mu\text{g/kg/day}$		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{c,d}	Inhalation ^e	
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
USC 20: Structural	Mushroom Houses	LP Handwand	EC	0.2 g ai/m ²	1600 m ²	0.431	0.207	6956	124862	4703
		Backpack Sprayer	EC	0.2 g ai/m ²	1600 m ²	2.49	0.283	1205	90882	1082
		LP Handwand	EC	1.6 g ai/L	150 L	0.323	0.155	9275	166482	6271
		Backpack Sprayer	EC	1.6 g ai/L	150 L	1.867	0.213	1607	121176	1442
Baseline PPE: Long pants, long sleeved shirts and chemical-resistant gloves.										
USC 25: Human Habitat and Recreation Areas	Residential Areas	ULV Aerial Mixer/Loader	EC	260 g ai/ha	3000 ha	56.99	17.83	439	1447	334
		ULV Aerial Applicator	EC	260 g ai/ha	3000 ha	11.956	0.78	2091	33077	1963
		ULV Ground M/L/A	EC	60.8 g ai/ha	1200 ha	63.878	7.712	391	3345	349
USC 25: Human Habitat and Recreation Areas	In and around buildings that house domestic animals, around yards, homes, processing plants, and other buildings: walls, ceilings, stanchions, windows, fences, garbage cans	LP Handwand	EC	1 g ai/m ²	496 m ²	0.668	0.32	37400	80556	25285
		Backpack Sprayer	EC	1 g ai/m ²	496 m ²	3.859	0.44	6479	58633	5816
		HP ^g Handwand	EC	1 g ai/m ²	496 m ²	3.958	1.07	6317	24113	4972
		LP Handwand	EC	10.54 g ai/L	150 L	2.131	1.021	11733	25272	7933
		Backpack Sprayer	EC	10.54 g ai/L	150 L	12.3	1.402	2033	18395	1824
		HP ^g Handwand	EC	10.54 g ai/L	3750 L	315.381	85.26	79	303	62

USC	Scenario	Application Equipment	Form	Max Rate	Area Treated/day	Daily Exposure µg/kg/day		Margins of Exposure		Combined MOE ^f
						Dermal ^a	Inhalation ^b	Dermal ^{a,d}	Inhalation ^e	
Mid-Level PPE: Cotton coveralls over long pants, long sleeved shirts, and chemical-resistant gloves.										
USC 25: Human Habitat and Recreation Areas	In and around buildings that house domestic animals, around yards, homes, processing plants, and other buildings: walls, ceilings, stanchions, windows, fences, garbage cans	HP Handwand	EC	10.54 g ai/L	3750 L	138.536	85.26	180	303	112
Baseline PPE: Long pants, long sleeved shirts, and chemical-resistant gloves.										
USC 27: Ornamentals Outdoors	Ornamentals	LP Handwand	EC	3000 g ai/ha	2 ha	8.086	3.874	3092	6659	2090
USC 27: Ornamentals Outdoors	Ornamentals	Backpack Sprayer	EC	3000 g ai/ha	2 ha	46.679	5.322	536	4847	481
		HP Handwand	EC	3000 g ai/ha	2 ha	47.876	12.943	522	1993	411

Shaded cells indicate MOEs that are less than target MOE.

^a Where dermal exposure $\mu\text{g/kg/day}$ = (unit exposure $\times$ area treated per day $\times$ use rate $\times$ 10 % dermal absorption)/70 kg bw

^b Where inhalation exposure $\mu\text{g/kg/day}$ = (unit exposure $\times$ area treated per day $\times$ use rate)/70 kg bw

^c Based on long-term oral NOAEL of 3.0 mg/kg bw/day from the rat chronic carcinogenicity study, target MOE is 100. Used for flour mills, greenhouse food uses, flour mill warehouses, food mills, and mushroom houses

^d Based on short-intermediate term oral NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE is 300. Used for the majority of scenarios except for the above-noted scenarios.

^e Based on short-intermediate term and long-term inhalation NOAEL of 25.8 mg/kg bw/day from the 90-day inhalation study, target MOE is 1000.

^f Calculated by summing the dermal and inhalation exposure and comparing to the short-to-intermediate term oral NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300 or the long-term oral NOAEL of 3.0 mg/kg bw/day from the rat chronic carcinogenicity study, target MOE of 100.

^g Backrubber assessed using open mix/load for liquids

^h Application by dust assessed using open mix/load for a wettable powder

ⁱ In large grain holding facilities, automated sprayers are used for treatment of grain along large conveyor belts. Exposure is estimated for the person adding malathion to the holding tank by using the open mix/load scenario in PHED for liquids.

^j High acreage vegetables are potato, beans, lentils, barley, canola, oats, wheat, rye, wild rice (cultivated), alfalfa, clover, sweet clover, canary grass (for seed), rape seed, rape, mustard, flax, tobacco

Only potatoes, beans and lentils are available with the wettable powder formulation.

^k Low acreage vegetables are asparagus beet, turnip, carrot, horseradish, parsnip, turnip top, salisfy, radish, rutabaga, sugar beets, garlic, leek, onion (bulb, green), shallot, lettuce (head and leaf), spinach, celery, endive, broccoli, brussel sprouts, cabbage, cauliflower, kale, kohlrabi, parsley, swiss chard, collard, watercress, dandelion, peas, eggplant, pepper, tomato, cucumber, melon, pumpkin, squash

^l Includes alfalfa, clover, sweet clover, canary grass (for seed)

^m Includes barley, canola, oats, wheat, rye, wildrice (cultivated), rapeseed, rape, mustard, flax

ⁿ Includes apricot, apple, pear, peach, plum, prune plum, cherry

^o Includes raspberry, boysenberry, blackberry, dewberry, loganberry, strawberry

^p Includes currant, gooscherry, blueberry

Table 2 Post-Application Exposure Estimates, MOEs and REIs for Malathion

Crop	Activity	TC (cm ² /hr)	Max Rate (g ai/ha)	DFR (Day 0) (µg/cm ²) ^a	Max # of App.	Interval between App.	Dermal Exposure (mg/kg bw/day) ^b	Dermal MOE (Day 0) ^c	REI ^d
GREENHOUSE VEGETABLES									
Greenhouse Lettuce	All activities	400	1375	2.75	2	10	0.012571	239	12 hrs
GREENHOUSE ORNAMENTALS									
Greenhouse Ornamentals	All activities	4000	976	1.952	4	10	0.08923	34 ^f	2 days
TERRESTRIAL FOOD CROPS									
Cereal Crops, Pasture and Range, Grasses of legumes being grown for hay	All activities	1500	1375	2.75	1	N/A	0.0471	530	12 hrs
ROOT AND TUBER VEGETABLES									
Potato	All activities	1500	1500	3	1	N/A	0.05142	486	12 hrs
Beets, Turnip, Carrot, Horseradish, Parsnip	All activities	2500	1500	3	1	N/A	0.08571	292	1 day
LEAVES OF ROOT AND TUBER VEGETABLES									
Sugar Beets, Turnip Top, Salsify, Radish, Rutabaga	All activities	1500	1500	3	1	N/A	0.05142	486	12 hrs
BULB VEGETABLES									
Onion, Garlic, Leek, Shallot	All activities	300	1377	2.75	1	N/A	0.00944	2648	12 hrs

Crop	Activity	TC (cm ² /hr)	Max Rate (g ai/ha)	DFR (Day 0) (µg/cm ²) ^a	Max # of App.	Interval between App.	Dermal Exposure (mg/kg bw/day) ^b	Dermal MOE (Day 0) ^c	REI ^d
LEAFY VEGETABLES									
Lettuce, Spinach, Celery, Collard, Kale, Parsley, Swiss Chard, Endive, Kohlrabi, Watercress, Dandelion	All activities	2500	1500	3	1	N/A	0.08571	292	1 day
Broccoli, Brussel Spouts, Cabbage, Cauliflower	All activities	5000	1500	3	1	N/A	0.171429	146	2 days
LEGUME VEGETABLES									
Beans, Lentils, Peas	All activities	2500	1500	3.13	2 (lentils)	7 days (lentils)	0.08948	279	1 day
FRUITING VEGETABLES									
Eggplant, Pepper, Tomato	All activities	1000	1500	2.876	4 (pepper)	7 days (pepper)	0.03287	760	12 hrs
CUCURBIT VEGETABLES									
Cucumber, Melon, Pumpkin, Squash	All activities	2500	1500	3	1	N/A	0.08571	292	1 day
POME FRUITS									
Apples, Apricots, Pears	Thinning	3000	3900	7.99	2	10 days	0.27398	91	3 days
	Hand Harvest, Irrigation	1500					0.1352	185	2 days
	All Other Activities	500	3900	7.99	2	10 days	0.04508	555	12 hrs

Crop	Activity	TC (cm²/hr)	Max Rate (g ai/ha)	DFR (Day 0) (µg/cm²) ^a	Max # of App.	Interval between App.	Dermal Exposure (mg/kg bw/day) ^b	Dermal MOE (Day 0) ^c	REI ^d
STONE FRUITS									
Peach, Plum, Prune, Cherry	Thinning	3000	3150	6.3	1	N/A	0.216	116	3 days
	All other activities	1500					0.108	231	1 day
BERRIES									
Blackberry, Boysenberry, Dewberry, Strawberry, Loganberry	All activities	1500	2125	4.44	2	7 days	0.0706	329	12 hrs
Raspberry	All activities	1500	2753	5.57	2	10 days	0.09548	262	1 day
Blueberry	All activities	5000	1023	2.45	3	4 days	0.13982	179	2 days
Currant, Gooseberry	All activities	1500	625	1.26	2	10 days	0.02168	1153	12 hrs
CEREAL GRAINS									
Barley, Canola, Oats, Wheat, Rye, Wild Rice (Cultivated)	All activities	1500	1469	2.938	1	N/A	0.05037	496	12 hrs
FORAGE, FODDER, AND STRAW OF CEREAL GRAINS									
Corn (grain, forage)	All activities	1000	1375	3.722	5	3 days	0.04254	588	12 hrs
NONGRASS ANIMAL FEEDS									
Alfalfa, Clover, Sweet Clover, Canary Grass (for seed)	All activities	1500	1500	3	2	14 days	0.05153	485	12 hrs

Crop	Activity	TC (cm ² /hr)	Max Rate (g ai/ha)	DFR (Day 0) (µg/cm ²) ^a	Max # of App.	Interval between App.	Dermal Exposure (mg/kg bw/day) ^b	Dermal MOE (Day 0) ^c	REI ^d
GRASS, FORAGE, FODDER, AND HAY OILSEED									
Rapeseed, Rape, Mustard, Flax	All activities	1500	935	1.87	1	N/A	0.03206	780	12 hrs
OTHER CROPS									
Asparagus	All activities	500	1500	3	1	N/A	0.01714	1458	12 hrs
Grapes	Girdling, Cane Turning	19300	1750	3.5	1	N/A	0.772	32	5 days
	Hand Harvest, Training, Tying, Leaf Pulling, Hand Pruning, Thinning	8500					0.34	74	4 days
	All other activities	700					0.028	893	12 hrs
Tobacco	All activities	2000	1054	2.108	1	N/A	0.04818	519	12 hrs
Cranberries	All activities	400	2760	5.52	1	N/A	0.02523	991	12 hrs
ORNAMENTALS OUTDOORS									
Ornamentals Outdoors	All activities	4000	3000	6.07	4	10	0.27748	90	3 days

Shaded cells indicate MOEs that are less than the target MOE, and therefore require a REI to mitigate exposure.

^a Dislodgeable foliar residue values were calculated using the standard default of 20% of the application rate for day 0 and 36% dissipation per day thereafter except for greenhouse ornamentals. For greenhouse ornamentals, chemical-specific DFR data generated from ARTF 055 was used. Dislodgeable foliar residue values are presented taking into account multiple applications. For example, if there are 2 applications, DFR values are presented for day 0 following the 2nd application, to include any possible accumulation of malathion residues.

^b Dermal exposure was calculated using the following equation: (Transfer co-efficient (cm²/hr) x Duration (8 hr/day) x DFR (µg/cm²) x dermal absorption (10%)/ Body Weight (70 kg)

^c Dermal MOE on Day 0 is the margin of exposure on the day of application. If there are multiple applications, the dermal MOE is presented for the day of the last application to account for any possible accumulation of malathion. Based on short-intermediate term oral NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE is 300 except for greenhouse lettuce, and greenhouse ornamentals where the long-term oral NOAEL of 3.0 mg/kg bw/day from the rat chronic carcinogenicity study was used, target MOE is 100.

^d A restricted entry interval is the duration of time which must elapse before residues decline to a level where entry into a treated area to perform a specific activity will result in a margin of exposure above the agency target.

^e This MOE is for the day following application of malathion. Since there was not a significant amount of accumulation of malathion residues observed in the greenhouse ornamental study, 2 applications in greenhouse lettuce is considered acceptable provided that there is at least a 10 day interval between applications to be consistent with ARTF 055 (shortest interval between applications was 9 days)

^f Chemical-specific data (ARTF 055) was used to establish the REI.

Appendix V Non-Occupational Exposure and Risk Assessment

Table 1 Adult Short-Intermediate Term Applicator Exposure and Risk Assessment on Residential Areas

Application Equipment	Data Source ^a	Formulation Rate (g ai/m ² , g ai/L or g ai per container)	Area Treated per Day ^b	Dermal Unit Exposure µg/kg handled	Dermal Exposure ^c µg/kg/day	Inhalation Unit Exposure µg/kg handled	Inhalation Exposure ^d µg/kg/day	Dermal MOE ^e	Inhalation MOE ^f	Combined MOE ^g
Residential Vegetables and Fruits: Homeowner wearing short sleeves, short pants, and no gloves										
Backpack Sprayer	PHED ^h	EC 3.5 g ai/L	20 L	10149.19	1.015	62.1	0.062	24633	415459	23212
Handheld Sprayer	ORETF ⁱ			109089	10.909	6.37	0.006	2292	4050235	2290
Ready-to-Use	ORETF ^j			130123	13.012	78.4	0.078	1921	329082	1910
Hose-End Sprayer	ORETF ^k	EC 138.5 g ai/container	1 container	105732	20.92	3.57	0.007	1195	3652580	1195
Handheld Sprayer	ORETF ^l	DU ^o 0.5 g ai/L	20 L	82741	1.182	23.66	0.003	21150	7633136	21090
Pump Duster	ORETF ^m	DU 25 g ai/container	1 container	354446	12.659	2711	0.968	1975	26647	1835
Outdoor Ornamentals, Flowers, Trees and Shrubs: Homeowner wearing short sleeves, short pants, and no gloves										
Backpack Sprayer	PHED ^h	EC 3.5 g ai/L	20 L	10149.19	1.015	62.1	0.062	24633	415459	23212
Handheld Sprayer	ORETF ⁱ			109089	10.909	6.37	0.006	2292	4050235	2290
Hose-End Sprayer	ORETF ^k	EC 138.5 g ai/container	1 container	105732	20.92	3.57	0.007	1195	3652580	1195

Application Equipment	Data Source ^a	Formulation Rate (g ai/m ² , g ai/L or g ai per container)	Area Treated per Day ^b	Dermal Unit Exposure µg/kg handled	Dermal Exposure ^c µg/kg/day	Inhalation Unit Exposure µg/kg handled	Inhalation Exposure ^d µg/kg/day	Dermal MOE ^e	Inhalation MOE ^f	Combined MOE ^g
Backpack Sprayer	PHED ^h	EC 0.263 g ai/m ²	100 m ²	10149.19	0.381	62.1	0.0233	65562	1105784	61782
Handheld Sprayer	ORETF ⁱ			109089	4.099	6.37	0.0023	6100	10780094	6096
Handheld Sprayer	ORETF ⁱ	DU ^o 0.5 g ai/L	20 L	82741	1.182	23.66	0.00388	21150	7633136	21090
Pump Duster	ORETF ^{im}	DU 20 g ai/container	1 container	354446	10.13	2711	0.7745	2469	33308	2293
Foundations, Exterior Wall Surfaces, Under Fences and Shrubs: Homeowner wearing short sleeves, short pants, and no gloves										
Handheld Sprayer	ORETF ⁱ	EC 32 g ai/L	20 L	82741	75.65	45.2	0.413	330	62431	329

Shaded cells indicate MOEs that are less than the target MOE, and therefore require a REI to mitigate exposure.

^a Dislodgeable foliar residue values were calculated using the standard default of 20% of the application rate for day 0 and 36% dissipation per day thereafter except for greenhouse ornamentals. For greenhouse ornamentals, chemical-specific DFR data generated from ARTF 055 was used. Dislodgeable foliar residue values are presented taking into account multiple applications. For example, if there are 2 applications, DFR values are presented for day 0 following the 2nd application, to include any possible accumulation of malathion residues.

^b Dermal exposure was calculated using the following equation: (Transfer co-efficient (cm²/hr) x Duration (8 hr/day) x DFR (µg/cm²) x dermal absorption (10%))/ Body Weight (70 kg)

^c Dermal MOE on Day 0 is the margin of exposure on the day of application. If there are multiple applications, the dermal MOE is presented for the day of the last application to account for any possible accumulation of malathion. Based on short-intermediate term oral NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE is 300 except for greenhouse lettuce, and greenhouse ornamentals where the long-term oral NOAEL of 3.0 mg/kg bw/day from the rat chronic carcinogenicity study was used, target MOE is 100.

^d A restricted entry interval is the duration of time which must elapse before residues decline to a level where entry into a treated area to perform a specific activity will result in a margin of exposure above the agency target.

^e This MOE is for the day following application of malathion. Since there was not a significant amount of accumulation of malathion residues observed in the greenhouse ornamental study, 2 applications in greenhouse lettuce is considered acceptable provided that there is at least a 10 day interval between applications to be consistent with ARTF 055 (shortest interval between applications was 9 days)

^f Chemical-specific data (ARTF 055) was used to establish the REI.

Table 2 Adult and Youth Acute to Short-Term Post-Application Exposure and Risk Assessment on Residential Gardens

Scenario		Application Rate	Transfer Coefficient (TC) (cm ² /hr)	Duration (hr)	Dermal Exposure ^a (µg/kg/day)	Dermal MOE ^b
Adult (70Kg)	Acute	138.9 g ai/product ^c	4000	0.67	84.841	295
	Short- Term				10.61	2357
	Acute	30 g ai/L ^d			367.54	68
	Short-Term				45.94	544
Youth (39Kg)	Acute	138.9 g ai/product ^c	2755	0.67	104.88	219
	Short-Term				131.1	816
	Acute	30 g ai/L ^d			454.36	51
	Short-Term				567.95	188

Shaded cells are below the target MOE

^a Dermal exposure = (dislodgeable foliar residue (16% application rate - acute; 2% application rate - short-term) x transfer co-efficient x duration (0.67 hrs) x dermal absorption (10% - where applicable)/Body weight (70 kg for adults, 39 kg for youth).

^b Adult MOE is based on the acute and short term oral aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300 for both the acute and short-term assessment. Youth MOE based on the acute oral aggregate BMDL₂₀ of 23 mg/kg bw/day, target MOE of 100 from the acute comparative cholinesterase assay with malathion/malaoxon, and the short-term aggregate dermal BMDL₂₀ of 107 mg/kg bw/day from the rabbit 21-day dermal study, target MOE of 100.

^c It was assumed that one whole product was applied to 100 m² of residential gardens (vegetables, fruits and ornamentals)

^d Only one domestic EUP (PCP# 8480) has this high rate for garden areas, which was interpreted as potentially including vegetable and fruit gardens, and ornamentals.

^e The MOE of 295 is considered acceptable since it approaches the target MOE of 300, and given that a high TC value was used to represent all activities in vegetable gardens and outdoor ornamentals and that the maximum application rate was used in the assessment.

Appendix VI Bystander Exposure Estimates and Risk Assessment

Table 1 Exposure Estimates and Margins of Exposure for Turf following Usage of Malathion in Mosquito Abatement Programs

Sub-Population	Application Method	Dermal Exposure (µg/kg/d) ^a	Inhalation Exposure (µg/kg/d) ^b	Oral Exposure (µg/kg/d)			Dermal MOE ^f	Inhalation MOE ^g	Oral MOE ^h	Combined MOE ⁱ
				Hand-to-Mouth ^c	Object-to-Mouth ^d	Ingestion of Soil ^e				
Adult (70 kg)	Ground ULV	0.1889	0.5733	N/A	N/A	N/A	132335	43610	N/A	32801
	Aerial ULV	1.885	0.255	N/A	N/A	N/A	13263	98204	N/A	11685
Youth (39 kg)	Ground ULV	2.335	1.029	N/A	N/A	N/A	45821	25075	N/A	16206
	Aerial ULV	23.3	0.457	N/A	N/A	N/A	4592	56465	N/A	4247
Toddler (15 kg)	Ground ULV	0.316	1.873	0.1216	0.0152	4.07 x 10 ⁻⁴	15815	2670	36441	2150
	Aerial ULV	3.15	1.001	1.213	0.1517	4.06 x 10 ⁻³	1585	4995	3652	905

^a Dermal exposure was calculated using the following formula and assumptions in malathion P/ACR2003-10: [turf transferable residue (5%) x deposition rate (15% for ground and 35% for aerial) x application rate (µg/cm²) x transfer coefficient (14500 cm²/hr adults, 9986 cm²/hr youth and 5200 cm²/hr toddlers) x duration (2 hr) x dermal absorption (10%, where applicable)] / body weight (70 kg adult, 39 kg youth, and 15 kg toddler)

^b Inhalation exposure was calculated using the following formula and assumptions outlined above: [amount applied/air concentration (12.6 mg/m³ ULV ground, and 0.054 mg/m³ aerial adults and youth, and 0.065 mg/m³ aerial toddlers) x fraction available in outdoor air (1% ground only) x inhalation rate (1.0 m³/hr adults and adolescents, 0.7 m³/hr toddlers) x exposure time (0.33 hr/day)] / body weight (70 kg adult, 39 kg youth, and 15 kg toddler)

^c Hand-to-Mouth exposure was calculated using the following formula and assumptions outlined above:

[dislodgeable foliar residue (5%) x deposition rate (15% ground, 35% aerial) x surface area (20 cm²) x hand-to-mouth events (20/hr) x saliva extraction factor (50%) x duration (2 hr/day)] / body weight (15 kg)

^d Object-to-Mouth was calculated using the following formula and assumptions outlined above: [dislodgeable foliar residue (20%) x deposition rate (15% for ground and 35% for aerial) x area of turf mouthed (25 cm²/day) x saliva extraction factor (50%)] / body weight (15 kg)

^e Ingestion of Soil was calculated using the following formula and assumptions outlined above: [application rate (µg/cm²) x deposition rate (15% for ground and 35% for aerial) x ingestion rate (0.1 g soil/day) x fraction available (100% available per cm soil) x conversion factor (0.67 cm³/g soil)] / body weight (15 kg)

^f Dermal MOE was calculated for adults using the oral short-to-intermediate term aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300. For youths, the BMDL₂₀ of 107 mg/kg bw/day from the 21-day dermal study was used for the assessment, target MOE of 100. For toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100.

^g Inhalation MOE was calculated for adults using the oral short-to-intermediate term aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300. For youths, the NOAEL of 25.8 mg/kg bw/day from the 90-day inhalation study, target MOE of 100. For toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100.

^h Oral MOE for toddlers was calculated using the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day from the rat developmental neurotoxicity study, target MOE of 100.

ⁱ Combined MOEs was calculated by summing the exposures from all relevant routes for adults and toddlers. For adults, the oral short-to-intermediate aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study was used, target MOE of 300. For toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100. For youth, route specific MOEs were aggregated using the following formula: Combined MOE = 1 / (1/MOE_{DERMAL} + 1/MOE_{INHALATION}), target MOE of 100.

Table 2 Exposure from Malathion and Malaoxon Residues on Outdoor Hard Surfaces

Sub-Population	Dermal Exposure (µg/kg bw/day) ^a			Incidental Oral Exposure (µg/kg bw/day) ^b			Dermal MOE ^e	Oral MOE ^f	Combined MOE ^g
	Malathion	Malaoxon ^c	Total Malathion ^d	Malathion	Malaoxon ^c	Total Malathion ^d			
Adult (70 kg)	1.95	0.217	7.2	N/A	N/A	N/A	3490	N/A	N/A
Youth (39 kg)	24.15	2.68	88.6	N/A	N/A	N/A	1208	N/A	N/A
Toddler (15 kg)	3.276	0.364	12	1.09	0.121	4	416	1249	312

^a Dermal exposure was calculated using the following formula and the assumptions outlined above: [transferable residue (10%) x deposition rate (35% for aerial applications) x application rate (µg/cm²) x duration (1 hr/day) x dermal absorption (10%, where applicable)] / body weight (70 kg adults, 39 kg youth, 15 kg toddler)

^b Oral exposure was calculated using the following formula and the assumptions outlined above: Hand-to-mouth exposure: [transferable residue (10%) x deposition rate (35% for aerial applications) x hand-to-mouth (20 events/hr) x saliva extraction factor (50%) x duration (1 hr/day)] / body weight (70 kg adults, 39 kg youth, 15 kg toddler)

^c Malaoxon residues were calculated by assuming the 10% of the total malathion residue is transformed into malaoxon, it was assumed that 90% of the residue remained as untransformed malathion.

^d Total malathion residues were calculated by adding the malathion residues to the malaoxon residues multiplied by the toxicity adjustment factor of 24.

^e Dermal MOE was calculated for adults using the oral short-to-intermediate term aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300. For youths, the BMDL₂₀ of 107 mg/kg bw/day from the 21-day dermal study was used for the assessment, target MOE of 100. For toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100.

^f Oral MOE for toddlers was calculated using the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day from the rat developmental neurotoxicity study, target MOE of 100.

^g Combined MOE for toddlers was calculated by summing the exposures from the dermal and non-dietary (incidental) oral route and comparing to the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day from the rat developmental neurotoxicity study, target MOE of 100.

Appendix VII Aggregate Acute and Short-Term Exposure and Risk Assessment

Table 1 Aggregate Exposure for PYO Operations

Crop ^a	Sub-Population	Application Rate (g ai/ha) ^b	Activity	Dermal MOE ^c	Dietary MOE ^c	Aggregate MOE ^d
Apples	Adults	3900	Hand Harvest	2820	2208	1239
	Youth			2097	1727	947
	Toddler			1305	646	432
Strawberries	Adults	2125	Hand Harvest	5015	3005	1879
	Youth			3729	2354	1443
	Toddler			2321	1039	718

^a Apples and strawberries are considered to be representative of all PYO orchard and berry crops for the purposes of assessing exposure.

^b Maximum listed label rates expressed in grams a.i./hectare.

^c Based on the acute aggregate oral NOAEL of 25 mg/kg bw/day from the rabbit developmental study for adults, target MOE of 300, or the acute aggregate oral NOAEL of 23 mg/kg bw/day from the acute comparative cholinesterase assay with malathion/malaoxon for youth and children, target MOE of 100.

^d Aggregate MOEs were calculated by summing the route-specific exposures and comparing to the acute aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study for adults, target MOE of 300, and 23 mg/kg bw/day from the acute comparative cholinesterase assay with malathion/malaoxon for youth and children, target MOE of 100.

Table 2 Aggregate Short-Term Risk Assessment

Sub-Population	Scenario	Total Dermal Exposure (µg/kg bw/day)	Dermal MOE ^a	Total Inhalation (µg/kg bw/day)	Inhalation MOE ^b	Total Oral Exposure (µg/kg bw/day)	Oral MOE ^c	Aggregate MOE ^d
Adult (70 kg)	Homeowner applying malathion using a hose-end sprayer to outdoor ornamentals and post-application exposure from gardening	31.53	793	0.007	3571429	7.3	3425	644
	Post-application exposure from mosquitoicide use (aerial ULV)	1.885	13263	0.0255	982048	7.3	3425	2714
	Post-application exposure to malaoxon from treated playstructures and decks	7.2	3472	N/A	N/A	7.3	3425	1724

Sub-Population	Scenario	Total Dermal Exposure (µg/kg bw/day)	Dermal MOE ^a	Total Inhalation (µg/kg bw/day)	Inhalation MOE ^b	Total Oral Exposure (µg/kg bw/day)	Oral MOE ^c	Aggregate MOE ^d
Youth (39 kg)	Post-application exposure from gardening in treated ornamentals, vegetables, and fruits	131.1	816	N/A	N/A	9.5	2421	610
	Post-application exposure from mosquitoicide use (aerial ULV)	23.3	4592	0.457	56455	9.5	2421	1542
	Post-application exposure to malaoxon from treated playstructures and decks	88.6	1208	N/A	N/A	9.5	2421	806
Toddler (15 kg)	Post-application exposure from mosquitoicide use (aerial ULV)	3.15	1587	1.001	4995	21.069	237	198
Toddler (15 kg)	Post-application exposure to malaoxon from treated playstructures and decks	12	417	N/A	N/A	23.7	211	140

^a Dermal MOE was calculated for adults using the oral short-to-intermediate term aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300. For youths, the BMDL₁₀ of 107 mg/kg bw/day from the 21-day dermal study was used for the assessment, target MOE of 100. For toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100.

^b Inhalation MOE was calculated for adults using the oral short-to-intermediate term aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300. For youths, the NOAEL of 25.8 mg/kg bw/day from the 90-day inhalation study, target MOE of 100. For toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100.

^c Oral MOE was calculated for adults using the oral short-to-intermediate term aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study, target MOE of 300. For youths, the oral BMDL₁₀ of 23 mg/kg bw/day from the acute comparative cholinesterase assay with malathion/malaoxon was used for the assessment, target MOE of 100, and for toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100.

^d Combined MOEs was calculated by summing the exposures from all relevant routes for adults and toddlers. For adults, the oral short-to-intermediate aggregate NOAEL of 25 mg/kg bw/day from the rabbit developmental study was used, target MOE of 300. For toddlers, the oral short-to-intermediate term aggregate NOAEL of 5 mg/kg bw/day was used from the rat developmental neurotoxicity study, target MOE of 100. For youth, route specific MOEs were aggregated using the following formula: Combined MOE = 1/(1/MOE_{DERMAL} + 1/MOE_{INHALATION} + 1/MOE_{ORAL}), target MOE of 100.

Appendix VIII Dietary Exposure and Maximum Residue Limits

Table 1 Acute Dietary Exposure and Risk for malathion

Probabilistic evaluation of exposure to main population at the 99.9th percentile. **Exp:** Exposure $\mu\text{g.kgBW}^{-1}\text{.day}^{-1}$; **ARD%:** Percent of Acute Reference Dose ($0.23 \text{ mg/kg}_{\text{BW}}/\text{day}$) for whole population; $0.08 \text{ mg/kg}_{\text{BW}}/\text{day}$ for females 13-49 yrs). Monte-Carlo iterations=500, seed=1. **Water Only:** Acute risk arising only from consumption of water, direct and indirect. Bold entries indicate risk exceeds Reference dose.

Population	Food and Water		Water Only	
	Exp	ARD (%)	Exp	ARD (%)
All infants	0.2325	101	0.2173	94
Children 1-2 yrs	0.1432	62	0.0855	37
Children 3-5 yrs	0.1303	57	0.0823	36
Children 6-12 yrs	0.1022	44	0.0509	22
Males 13-19 yrs	0.1922	84	0.0786	34
Males 20-49 yrs	0.1059	46	0.0628	27
Females 13-49 yrs	0.0715	89	0.0597	75
Adults 50+ yrs	0.0569	25	0.0435	19

Table 2 Chronic Dietary Exposure and Risk for malathion

Probabilistic evaluation of exposure to Main population. **Exp:** Exposure $\mu\text{g/kg bw/day}$; **ADI%:** Percent of Chronic Reference Dose (0.3 mg/kg bw/day for whole population).

Population	Exp ($\mu\text{g/kg bw/day}$)	ADI (%)
General Population	9.5	32
All Infants	7.6	25
Children 1-2 yrs	19.7	66
Children 3-5 yrs	19	64
Children 6-12 yrs	13.1	44
Youth 13-19 yrs	9.5	32
Adults 20-49 yrs	8.5	28
Females 13-49 yrs	7.3	24
Adults 50+ yrs	6.9	23

Table 3 Drinking Water Exposure Estimated from Level II Models and Monitoring Data

	Groundwater Concentration (µg/L)		Reservoir						Dugout ⁵				
	Acute	Chronic	Acute Concentration (µg/L)			Chronic Concentration (µg/L)			Acute Concentration (µg/L)		Chronic Concentration (µg/L)		
			Apple	Corn	Alfalfa	Apple	Corn	Alfalfa	Corn	Alfalfa	Corn	Alfalfa	
Upper Bound	0.0961	0.022	14.4 ³	12.02 ³	17.9 ³	0.4 ⁴	0.22 ⁴	1.014	14.53	12.2 ³	0.34 ⁴	0.59 ⁴	
Lower Bound			1.51			0.12			1.51		0.12		
OXON	expressed as malathion (highest upper bound x 24)				429.6				24.2				

¹ 95th percentile of the maximum detected concentration from surface water monitoring studies² 95th percentile of the mean concentration from each study site including ½ LOD for non-detects³ 90th percentile of the annual peak concentrations predicted by PRZM-EXAMS⁴ 90th percentile of the annual average concentrations predicted by PRZM-EXAMS⁵ dugout value not determined for apples because this is not a crop that is common around dugouts (typically prairie provinces)

Table 4 Maximum Residue Limits (ppm)

Entries in **bold** denote registered or supported commodities in Canada. Conventions as follows: **none**, no US tolerance; **R**, Tolerance proposed for revocation in US; **GMRL**, Missing Canadian MRL are still subject to the General Maximum Residue Limit policy assigning default value of 0.1 ppm until a new value is promulgated. This policy is under review. **GMRL***: use of GMRL likely to trigger trade issues.

Commodity	CDN	US	CODEX	Commodity	CDN	US	CODEX
Alfalfa, seed	GMRL	none		Mango	GMRL	8	
Almond	GMRL	8 R		Milk, fat	GMRL	0.5	
Apple	2	8	0.5	Mushroom	8	8	
Apricot	8	8		Mustard	GMRL		2
Asparagus	6	8	1	Nectarine	6	8	
Avocado	8	8		Oat	GMRL	8	
Barley	GMRL	8		Okra	3	8	
Bean	2	8	1	Onion, dry	0.5	8	1
Bean, dry	2	8	2	Onion, green	3	8	5
Beef	GMRL	4 R		Orange	GMRL*	8	7
Beet	0.5	8	0.5	Papaya	8	1	
Beet, sugar, roots	0.5	1 R	0.5	Parsley	6	none	
Beet, sugar, tops	0.5	8 R	0.5	Parsnip	0.5	8	
Blackberry	8	8		Passion fruit	GMRL	8	
Blueberry	8	8	10	Pea	0.5	8	
Boysenberry	8	8		Peavine	0.5	8 R	
Broccoli	0.5	none		Peach	6	8	
Brussels sprout	6	none		Peanut	GMRL	8 R	
Cabbage	6	none		Pear	2	8	
Cantaloupe	8	8		Pecan	8	8	
Carrot	0.5	8	0.5	Pepper, chili, dry	0.5	8	
Cauliflower	0.5	none		Pepper	0.5	8	
Celery	1	none		Peppermint	8	8	1
Chayote	GMRL	8		Pineapple	8	8	0.1

Commodity	CDN	US	CODEX	Commodity	CDN	US	CODEX
Cherry	6	8		Plum, prune	8	8 R	
Chestnut	GMRL	1		Pork	GMRL	4 R	
Collards	0.5	none		Potato	0.5	8	
Corn, sweet	GMRL	2		Poultry	GMRL	4 R	
Corn, grain	GMRL	8		Pumpkin	3	8	0.5
Cottonseed	GMRL	2		Quince	2	8	
Cranberry	8	8 R		Radish	0.5	8	
Cucumber	3	8	0.2	Rapeseed (canola)	GMRL	none	
Currant	8	8		Raspberry	8	8	8
Dandelion	6	none		Rice	8	8	
Date	GMRL	8		Rice, wild	8	8	
Dewberry	8	8		Rutabaga	0.5	8	
Eggplant	0.5	8		Rye	2	8	
Endive	6	none		Salsify	3	8	
Fig	GMRL	8		Shallot	3	none	
Flaxseed	GMRL	0.1		Sheep	GMRL	4 R	
Garlic	0.5	8		Sorghum	GMRL	8	3
Goat	GMRL	4 R		Spcarmint	8	8	
Gooseberry	8	8		Spinach	6	none	3
Grape	8	8	5	Squash	3	8	
Grapefruit	P	8	7	Strawberry	8	8	1
Guava	GMRL	8		Sunflower	GMRL	8 R	
Honeydew	8	8		Swiss Chard	0.5	none	
Hop	GMRL	1		Tangerine	GMRL*	8	5
Horse	GMRL	4 R		Tomatillo	3	8	
Horseradish	0.5	8		Tomato	3	8	0.5
Kale	6	none		Tomato, juice	3	8	0.01
Kohlrabi	0.5	none		Turkey	GMRL	4 R	
Kumquat	GMRL	8		Turnip, greens	0.5	8	5
Leek	3	8		Turnip, root	0.5	8	0.2
Lemon	GMRL*	8	7	Walnut	GMRL	8	

Commodity	CDN	US	CODEX	Commodity	CDN	US	CODEX
Lentil	3	8 R		Watercress	6	none	
Lettuce	6	none		Watermelon	8	8	
Lime	GMRL*	8	7	Wheat	2	8	0.5
Loganberry	8	8		Wheat, flour	2	8	0.2
Macadamia nut	GMRL	1					

Appendix IX Environmental Fate of malathion and its transformation products

Study type	Test material	Study Conditions	Value or Endpoint	Interpretation	Major transformation products	Reference
Abiotic transformation						
Hydrolysis	Malathion	25 °C; 28 d	Half-life: pH 5 107 d pH 6.1 42 d pH 7 6.2 d pH 8 1.5 d pH 9 0.5 d	hydrolysis is an important route of transformation under neutral and alkaline conditions; malathion will be more persistent at lower temperatures and under acidic conditions	The following compounds were identified as hydrolysis transformation products: diethyl fumarate, dimethyl phosphorodithioic acid, malathion monocarboxylic acid and ethyl hydrogen fumarate. Ethyl hydrogen fumarate is a hydrolysis transformation product of diethyl fumarate.	PMRA 1318327 PMRA 1318318
		6°C; 6 months	Half-life: pH 6.1 212 d			
	Malaoxon	25 °C; 31 d	Half-life: pH 5 32.5 d pH 7 8.8 d pH 9 0.18 d	hydrolysis is an important route of transformation under neutral and alkaline conditions; malaoxon will be more persistent under acidic conditions	pH 5: Unidentified transformation product (U-1). pH 7: Desmethyl malaoxon, α and β malaoxon and disulphide dimer (U-5) pH 9: Diethyl fumarate, diethyl mercaptosuccinate, α and β malaoxon monoacids, disulfide dimer (U-3).	PMRA 1309298
Phototransformation soil	Malathion	sandy loam soil, pH 6.5, 23.5 °C; 35 d	Half-life: 173 d	Not a major route of transformation	Major transformation products were not formed (such as > 10% of applied a.r.)	PMRA 1711384 PMRA 1318327
Phototransformation water	Malathion	25 °C; 30 d	Half-life: pH 4 94 d (photosensitized) pH 4 156 d (non-photosensitized)	not an important route of transformation in distilled water; may be more important in natural waters if photosensitizing agents are present	Major transformation products were not formed (such as > 10% of applied a.r.)	PMRA 1711384 PMRA 1318327
		22°C; 6 months	16 hr (coloured river water) 8 d (filtered river water) 42 d (distilled water)			PMRA 1318319 PMRA 1318318

Study type	Test material	Study Conditions	Value or Endpoint	Interpretation	Major transformation products	Reference
Biotransformation						
Soil - aerobic	Malathion	92 days; loam soil; 22°C; pH 6.1; % OM 2.0	DT ₅₀ : 0.2 d	Non persistent	di-carboxylic acid of malathion	PMRA 1711384
		4 soils: 120 days; 25°C; pH 6.3 - 8.1; % OM 0.86 - 3.57.	DT ₅₀ : 4.0 hr to 6.1 hr	Non persistent	mono and di-carboxylic acid of malathion	PMRA 1318327 PMRA 1181688
		Open literature studies (laboratory and field) reported in EFED RED (2006)	DT ₅₀ : 8.2 hr to 2 d	Non persistent	Not available	PMRA 1711384
	Malaoxon monocarboxylic acid (MCA) of malathion dicarboxylic acid of malathion	5 days; silty loam soil	DT ₅₀ : 6.5 d (pH 6.2) to 3.5 d (8.2)	Non persistent	Not determined.	PMRA 1523034
		4 soils: 120 days; 25°C; pH 6.3 - 8.1; % OM 0.86 - 3.57.	DT ₅₀ : 2.8 hr - 17.3 hr	Non persistent	Not reported	PMRA 1181688
		4 soils: 120 days; 25°C; pH 6.3 - 8.1; % OM 0.86 - 3.57.	DT ₅₀ : 1.2 d - 5.3 d	Non persistent	Not reported	PMRA 1181688
Soil - anaerobic	Malathion	sandy loam soil (pH 7.8) and water (pH 8.7); flooded conditions	DT ₅₀ : 2.5 d (soil and water)	Non persistent	Water phase: monocarboxylic acid of malathion, demethyl monocarboxylic acid, dicarboxylic acid and demethyl dicarboxylic acid. Soil phase: No major transformation products were detected > 10% of applied a.r.	PMRA 1711384
	Monocarboxylic acid (MCA) of malathion		DT ₅₀ : 11d (soil and water)	Non persistent		
Water/sediment - aerobic	Malathion	Two systems: 120 d; 20°C; water phase (pH 8.1 - 8.4), sediment phase (pH 7.4 - 7.8). Flooded sandy loam soil (pH 8.5); water phase (pH 7.8).	whole system DT ₅₀ : 8 hr - 10 hr water phase DT ₅₀ : 8 hr - 10 hr	Non-persistent	Monocarboxylic acid and dicarboxylic acid of malathion	PMRA 1181694
			DT ₅₀ : 2.6 d (soil); 1.1 d (water phase)	Non persistent	monocarboxylic and dicarboxylic acid of malathion, demethyl monocarboxylic acid, and demethyl dicarboxylic acid.	PMRA 1711384
		Open literature studies (laboratory and field) reported in EFED RED (2006)	DT ₅₀ : 0.5 - 10 d	Non-persistent	Not reported	PMRA 1711384

Study type	Test material	Study Conditions	Value or Endpoint	Interpretation	Major transformation products	Reference
Water/sediment-an aerobic	Monocarboxylic acid (MCA) of malathion	Water pH 7.3; seawater pH 8.1, salinity 25 ‰	DT ₅₀ : 19 d (22 °C) and 55 d (6°C), nonfiltered river water	Non persistent to slightly persistent in freshwater and seawater; slightly to moderately persistent at lower temperatures (such as 6 °C)		PMRA 1318318
			DT ₅₀ : 7 d (22 °C) and 53 d (6 °C), filtered river water			
			DT ₅₀ : 6 d (22 °C) and 41 d (6 °C), seawater			
	Dicarboxylic acid of malathion	Two systems: 120 d; 20 °C; water phase (pH 8.1 - 8.4), sediment phase (pH 7.4 - 7.8).	whole system DT ₅₀ : 3 d - 4 d water phase DT ₅₀ : 3 d - 4 d	Non-persistent		PMRA 1181694
		Sandy loam hydro-soil (pH 8.5) and water (pH 7.8).	DT ₅₀ : 3 d	Non persistent		PMRA 1711384
		Two systems: 120 d; 20 °C; water phase (pH 8.1 - 8.4), sediment phase (pH 7.4 - 7.8).	whole system DT ₅₀ : 13 d - 21 d water phase DT ₅₀ : 15 d - 17 d	Non to slightly persistent		PMRA 1181694
Water/sediment-an aerobic	Malathion	118 d; 22 °C; pH 7.8, %OM 0.7%, clay 19.5%	Half-life: 2.5 d	Non-persistent	Monocarboxylic acid and dicarboxylic acid of malathion, demethyl monocarboxylic and demethyl dicarboxylic acid	PMRA 1318327
Foliar dissipation	Malathion		Half-life (foliar): 5.5d; representative of 90 th percentile dissipation half-life on plant surfaces.	Non persistent	Not reported	PMRA 1711384
Mobility						
Adsorption/desorption	Malathion	Four soils; pH 6.1 - 7.4; % OM 0.4 - 1.4	Freundlich K _{oc} : 0.83 - 2.47 K _{oc} : 151 - 183	Moderate mobility in sandy loam, sand, loam and silt loam soils; adsorption was correlated with organic carbon content	Not reported	PMRA 1711384
Soil column leaching	Malaoxon	Not available.	Detected in leachate and soil extracts in concentrations of > 0.12% AR (> 6 ug/L.)	Malaoxon may be susceptible to leaching		PMRA 1711384
Field studies						
Field dissipation	Malathion	Georgia (soil type not specified)	DT ₅₀ : < 1 d Malathion detected below 30 cm depth in soil	Non persistent	Not reported	PMRA 1711384
		California (soil type not specified)	DT ₅₀ : < 0.2 d	Non persistent	Not reported	PMRA 1711384

Study type	Test material	Study Conditions	Value or Endpoint	Interpretation	Major transformation products	Reference
		Open literature studies reported in EFED RED (2006); sites and soil types not specified)	No residues after 6 months; 85% transformation in 3 d; 97% transformation in 8 days.	Non persistent	Not reported	PMRA 1318327
Flooded soil, field	Malathion	Missouri; flooded plots; pH 6.1 - 7.4	DT ₅₀ : < 1 d	Non persistent	Not reported	PMRA 1318327

Appendix X Environmental toxicity of malathion and its transformation products

Organism	Study type	Species	Test material	Endpoint	Value* (effect)	Effect of concern	Reference
Terrestrial Species							
Invertebrates	Acute contact	Earthworm (<i>Eisenia foetida</i>)	Technical	14-d LC ₅₀	42 - 95 mg a.i./kg soil	mortality	PMRA 1897569
		Earthworm (<i>Enchytraeus albidus</i>)	Technical	21-d LOEC	6.6 - 23.2 mg a.i./kg soil	reduced cocoon production	
		Honey bee (<i>Apis mellifera</i>)	Technical	48-h LD ₅₀	0.2 - 0.38 µg ai/bee		PMRA 1711388
		Honey bee (<i>Apis mellifera</i>)	Technical	96-h LD ₅₀	0.709 µg ai/bee		
		Honey bee (<i>Apis mellifera</i>)	Technical	N.R. LD ₅₀	0.27 µg ai/bee		
		Honey bee (<i>Apis mellifera</i>)	57 EC formulation	8-h foliar LD ₅₀	< 1.6 µg ai/bee		
		Beneficial arthropods	n/a	Field studies showed that malathion is toxic to beneficial insects			
Birds ¹	Acute oral	Mallard duck (<i>Anas platyrhynchos</i>)	Technical	14-d LD ₅₀	1485 mg ai/kg bw (1020 - 2150)	mortality	PMRA 1318327
		Ring-necked pheasant (<i>Phasianus colchicus</i>)		14-d LD ₅₀	167 mg ai/kg bw (120-231)		
		Horned lark (adult) (<i>Eremophila alpestris</i>)		14-d LD ₅₀	403mg ai/kg bw (247-658)		
		Sharp tailed grouse (<i>Tympanuchus phasianellus</i>)		LD ₅₀	220 mg ai/kg bw (171 -240)		
		Chicken (<i>Gallus gallus</i>)		LD ₅₀	948 mg ai/kg bw		
		Mallard duck (<i>Anas platyrhynchos</i>)		8-d LC ₅₀	> 5000 mg ai/kg diet	mortality	
		Bobwhite quail (<i>Colinus virginianus</i>)		8-d LD ₅₀	> 276 mg a.i./kg bw/day		
		Ring-necked pheasant (<i>Phasianus colchicus</i>)		8-d LC ₅₀	3497 mg ai/kg diet (2959-4011)		
	Dietary	Bobwhite quail (<i>Colinus virginianus</i>)	Technical	8-d LD ₅₀	371 mg a.i./kg bw/day		
		Ring-necked pheasant (<i>Phasianus colchicus</i>)		8-d LC ₅₀	2639 mg ai/kg diet (2220 - 3098)		
		Japanese quail (<i>Coturnix japonica</i>)		8-d LD ₅₀	156 mg a.i./kg bw/day		
		Japanese quail (<i>Coturnix japonica</i>)		8-d LC ₅₀	2962 mg ai/kg diet (2453 - 3656)		
		Japanese quail (<i>Coturnix japonica</i>)		8-d LD ₅₀	598 mg a.i./kg bw/day		
		Mallard duck (<i>Anas platyrhynchos</i>)		NOEC	1200 mg ai/kg diet	reproduction	
		Bobwhite quail (<i>Colinus virginianus</i>)		NOEL	68 mg a.i./kg bw/day		
		Bobwhite quail (<i>Colinus virginianus</i>)		NOEC	110 mg ai/kg diet (maternal)	reproduction	
	Reproduction	Bobwhite quail (<i>Colinus virginianus</i>)		NOEL	11.7 mg a.i./kg bw/day		

Organism	Study type	Species	Test material	Endpoint	Value* (effect)	Effect of concern	Reference	
Mammals	Acute oral	Wistar rat	Technical	LD ₅₀	1580 mg a.i./kg bw, (♂/♀)	mortality	PMRA 1621981	
				LD ₅₀	8000 mg a.i./kg bw, (♂/♀)			
		Swiss mouse Sprague-Dawley rat		LD ₅₀	6100 mg a.i./kg bw, (♀)			
				LD ₅₀	5400/5700 mg ai/kg bw, (♂/♀)			
				LD ₅₀	5000 mg ai/kg bw, (♂/♀)			
				LD ₅₀	8200 mg ai/kg bw, (♂/♀)			
				LD ₅₀	6156/4061 mg ai/kg bw, (♂/♀)			
	Dietary	F-344 rat	Technical	29/30 d NOAEL	1036/1134 mg ai/kg diet, (♂/♀)	reduced body weight gain		
				90 d NOAEL	679.6/784 mg ai/kg diet, (♂/♀)			
	Reproduction (2-generation) ²	Sprague-Dawley rat		Parental NOAEL	394/451 mg ai/kg bw /day, (♂/♀)	decreased body weight	PMRA 1318327	
								PMRA 1621983
				Reproductive NOAEL	612/703 mg ai/kg bw/day, (♂/♀)		PMRA 1621986	
							PMRA 1621984	
					Offspring NOAEL	394/451 (♂/♀), mg ai/kg bw/day, (♂/♀)	decreased body weight	PMRA 1621985
					PMRA 1621981			
Freshwater Organisms								
Pelagic Invertebrates	Acute	<i>Daphnia magna</i>	malathion, 57 EC	48-h LC ₅₀	2.2 ug ai/L (1.9 - 2.5)	immobility	PMRA 1711388	
			malathion, 95% ai	48-h LC ₅₀	1.0 ug ai/L (0.7 - 1.4)			
	Chronic		malathion, 94% ai	21 - d NOEC	0.06 ug ai/L			
			malathion	21 - d NOEC	0.15 and 0.3 ug ai/L			
	Acute	<i>Daphnia pulex</i>	malathion, 95% ai	48-h LC ₅₀	1.8 ug ai/L (1.4 - 2.4)			
	Acute	Daphnid (<i>Simocephalus serrulatus</i>)	Malathion, 95% ai	48 - h LC ₅₀	0.69 ug ai/L (0.44 - 0.79)			
	Acute	Glass shrimp (<i>Palaemonetes kadiakensis</i>)		96 - h LC ₅₀	12 ug ai/L (NR)			
Benthic Invertebrates	Acute	Crayfish (<i>Orconectes nais</i>)	malathion, 95% ai	96 - h LC ₅₀	180 ug ai/L (140 - 230)	mortality	PMRA 1711388	
		Amphipod (<i>Gammarus lacustris</i>)	malathion technical	48 - h LC ₅₀	1.8 ug ai/L (1.3 - 2.4)			
		Amphipod (<i>Gammarus fasciatus</i>)	malathion, 95% ai	96 - h LC ₅₀	0.5 ug ai/L (NR)			
			malathion	LC ₅₀	0.8 ug ai/L (NR)			

Organism	Study type	Species	Test material	Endpoint	Value* (effect)	Effect of concern	Reference
Aquatic insects	Acute	Ostracod (<i>Cypridopsis vidua</i>)	Malathion, 95% ai	48 - h LC ₅₀	47 ug ai/L. (32 - 69)	n/a	PMRA 1711388
		Isopod (<i>Asellus brevicaudus</i>)	Malathion, 95% ai	96 - h LC ₅₀	3000 ug ai/L. (1500-8500)		
		Stonefly (<i>Claasemia sabulosa</i>)	malathion, 95% ai	LC ₅₀	2.8 ug ai/L. (1.4 - 4.3)		
		Stonefly (<i>Pteronarcella badia</i>)		LC ₅₀	1.1 ug ai/L. (0.78 - 1.5)		
		Stonefly (<i>Isoperla</i> sp.)		LC ₅₀	0.69 ug ai/L. (0.2 - 2.4)		
		Damselfly (<i>Lestes congener</i>)		LC ₅₀	10 ug ai/L. (6.5 - 15.0)		
		Caddisfly (<i>Hydropsyche</i> sp.)		LC ₅₀	5.0 ug ai/L. (2.9 - 8.6)		
		Caddisfly (<i>Limnephilus</i> sp.)		LC ₅₀	1.3 ug ai/L. (0.77 - 2.0)		
		Snipefly (<i>Atherix variegata</i>)		LC ₅₀	385 ug ai/L. (245 - 602)		
		Fresh water mussel (<i>Anodonta anatina</i>)	malathion, 95% ai	96-h LC ₅₀	80 ug ai/L.		
Molluscs	Acute	Bivalve (<i>Lamellidens corrianus</i>)	malathion 50 EC	96-h LC ₅₀	59 - 142 ug ai/L.	mortality	PMRA 1711388
Fish	Acute	Rainbow trout (<i>Oncorhynchus mykiss</i>)	malathion, 95% ai	96-h LC ₅₀	120 ug ai/L. 4ug ai/L. (2-7)	mortality	PMRA 1711388
	Chronic		malathion, 94% ai	97-d NOEC LOEC	21ug ai/L. 44 ug ai/L.	n/a	
	Acute	Bluegill sunfish (<i>Lepomis macrochirus</i>)	malathion, 95% ai	96-h LC ₅₀	20 ug ai/L. (16-25)	mortality	PMRA 1711388
			malathion, 95%	96-h LC ₅₀	30 ug ai/L. (10-88)		
	Chronic		malathion	300-d NOEC	7.4 ug ai/L.	n/a	PMRA 1730051
	Acute	Redear sunfish (<i>Lepomis microlophus</i>)	malathion, 95% ai	96-h LC ₅₀	62 ug ai/L. (58-67)	mortality	PMRA 1711388

Organism	Study type	Species	Test material	Endpoint	Value* (effect)	Effect of concern	Reference
	Acute	Yellow perch (<i>Perca flavescens</i>)	malathion, 95% ai	96-h LC ₅₀	263 ug ai/L. (205-338)		
		Largemouth bass (<i>Micropterus salmoides</i>)			250 ug ai/L. (229-310)		
		Carp (<i>Cyprinus carpio</i>)			6590 ug ai/L. (4920-8820)		
		Channel catfish (<i>Ictalurus punctatus</i>)			7620 ug ai/L. (5820-9970)		
		Coho salmon (<i>Oncorhynchus kisutch</i>)			170 ug ai/L. (160-180)		
		Cutthroat trout (<i>Oncorhynchus clarki</i>)			174 ug ai/L. (112-269)		
		Brown trout (<i>Salmo trutta</i>)			101 ug ai/L. (84-115)		
		Lake trout (<i>Salvelinus namaycush</i>)			76 ug ai/L. (47-123)		
		Black bullhead catfish (<i>Ameiurus melas</i>)			11700 ug ai/L. (9600-14100)		
		Green sunfish (<i>Lepomis cyanellus</i>)			1460 ug ai/L. (900-2340)		
		Walleye (<i>Stizostedion vitreum</i>)			64 ug ai/L. (59-70)		
		Tilapia (<i>Oreochromis</i> spp.)			2000 ug ai/L. (N.R.)		
		Goldfish (<i>Carassius auratus</i>)			10700 ug ai/L. (8340-13800)		
	Chronic	Goldfish (<i>Carassius auratus</i>)	malathion	9 d (eggs) NOEC	100-280 ug ai/L.	n/a	PMRA 1730051
	Acute	Fathead minnow (<i>Pimephales promelas</i>)	malathion	96-h LC ₅₀	8650 ug ai/L. (6450-11500)	mortality	PMRA 1711388
	Chronic	Fathead minnow (<i>Pimephales promelas</i>)	malathion, technical	158 d NOEC 158 d LOEC	ND ug ai/L.	350 n/a	
	Chronic	Fathead minnow (<i>Pimephales promelas</i>)	malathion	300 d NOEC	200 ug ai/L.	n/a	PMRA 1730051

Organism	Study type	Species	Test material	Endpoint	Value* (effect)	Effect of concern	Reference
Freshwater algae and vascular plants	Acute	Fathead minnow (<i>Pimephales promelas</i>)	diethyl fumarate	96-h LC ₅₀	4500 ug ai/L.	mortality	PMRA 1711388
			dimethyl phosphorodithioc acid		23500 ug ai/L.		
			2-mercapto diethyl succinate		35000 ug ai/L.		
			dimethylphosphorothionic acid		42500 ug ai/L.		
			maleic acid		5000 ug ai/L.		
			diethyl maleate		18000 ug ai/L.		
			dimethyl phosphate		18000 ug ai/L.		
			dimethyl phosphite		225000 ug ai/L.		
			thioglycolic acid		30000 ug ai/L.		
			diethyl succinate		140000 ug ai/L.		
			diethyl di-tartrate		650000 ug ai/L.		
			bis (hydroxymethyl) phosphinic acid		29000 ug ai/L.		
			ethylene phosphite		34000 ug ai/L.		
		wild caught fish	2-mercapto diethyl succinate		320 ug ai/L.		
		Eastern mudminnow (<i>Umbra pygmaea</i>)	diethyl fumarate	14 d LC ₅₀	4200 ug ai/L.		
			dimethyl phosphorodithioc acid	4 - 14 d LC ₅₀	14500-17000 ug ai/L.		
	Chronic	American flagfish (<i>Jordanella floridae</i>)	malathion, technical	110 d NOEC	8.6 ug ai/L.	11 n/a	
				110 d LOEC	ug ai/L.		
			malathion	30 d NOEC	8.6-19 ug ai/L.		
Freshwater algae and vascular plants	No available data						
Amphibians	Acute	Fowler's toad (<i>Bufo woodhousei</i>), tadpole stage	malathion	96-h LC ₅₀	420 ug ai/L.	mortality	PMRA 1711388
				24-h LC ₅₀	1900 ug ai/L.		
	Acute	Western chorus frog (<i>Pseudacris triseriata</i>), tadpole stage		96-h LC ₅₀	200 ug ai/L.		
Invertebrates	Acute	Mysid (<i>Mysidopsis bahia</i>) Pink shrimp (<i>Penaeus duorarum</i>) Eastern oyster (<i>Crassostrea virginica</i>) Blue crab (<i>Callinectes sapidus</i>)	malathion, 94% ai malathion, 95% ai malathion, 95% ai malathion, 57 EC malathion, 95% ai	Marine/estuarine organisms		(NR) Mortality	PMRA 1711388
				96- h LC ₅₀	2.2 ug ai/L. (1.5-2.6)		
				48- h LC ₅₀	280 ug ai/L.		
				96- h LC ₅₀	> 1000 ug ai/L.		
				96-h LC ₅₀	29620 ug ai/L. (NR)		
				48- h LC ₅₀	> 1000 ug ai/L.		

Organism	Study type	Species	Test material	Endpoint	Value* (effect)	Effect of concern	Reference
Fish	Acute	Spot (<i>Leiostomus xanthurus</i>)	malathion, 95% ai	48-h LC ₅₀ flowthrough	320 ug ai/L.	(NR)	PMRA 1730051
		Striped mullet (<i>Mugil cephalus</i>)	malathion, 95% ai	48-h LC ₅₀ flowthrough	330 ug ai/L. (NR)		
		Longnose killifish (<i>Fundulus similis</i>)	malathion, 95% ai	48-h LC ₅₀ flowthrough	150 ug ai/L. (NR)		
		Striped bass (<i>Morone saxatilis</i>)	malathion, 95% ai	acute, 96 hr	60 ug ai/L. (NR)		
		Sheepshead minnow (<i>Cyprinodon</i> <i>variegatus</i>)	malathion, 95% ai	48-h LC ₅₀ flowthrough	33 ug ai/L. (14-63)		
			malathion, 57 EC	96-h LC ₅₀	55 ug ai/L. (NR)		
	Chronic	Sheepshead minnow (<i>Cyprinodon</i> <i>variegatus</i>)	malathion	140 d NOEC	<9 - 18 ug ai/L.	n/a	
Marine/Estuarine Algae and plants	No available data						

* Confidence interval shown in parentheses.

¹ - Avian endpoints expressed as a concentration (LC₅₀, mg a.i./kg diet) were converted to a daily exposure dose per individual (LD₅₀ mg a.i./kg bw/day) using the following equation:

Daily dose (mg ai/kg bw/day) = Concentration in food (mg ai/kg diet) x FIR (kg diet/day) : BW (kg) where: FIR = Food Ingestion Rate and BW = Body Weight. Default bird body weights were obtained from Dunning 2008; FIR were calculated based on the "all birds" equation from Nagy 1987.

Dunning, Jr., John B. (Editor). 2008. *CRC Handbook of Avian Body Masses*.
CRC Press, Inc. 2000 Corporate Blvd., N.W., Boca Raton, Florida, 33431.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. *Ecological Monographs* 57:111-128.

² - Information related to the two-generation reproduction toxicity study was reviewed from several sources.

Appendix XI Summary of screening level risk assessment of malathion to terrestrial invertebrates

Organism	Application rate (g a.i./ha)*	Endpoint reported	Endpoint used for risk assessment**	EEC***	Risk Quotient	LOC exceeded
Earthworm (<i>Eisenia foetida</i>)	425	LC ₅₀ = 42 mg ai/kg soil	21 mg ai/kg soil	0.19 mg ai/kg soil	<0.1	No
	3952.5 (2x)			1.81 mg ai/kg soil	<0.1	No
Honey bee (<i>Apis mellifera</i>)	425	LD ₅₀ = 0.2 ug ai/bee	224 g ai/ha	425 g ai/ha	1.9	Yes
	3952.5 (2x)			3952.5 g ai/ha	18	Yes

*** Application rate represents the minimum and maximum (cumulative) applications rates as indicated on labels.

** Earthworm endpoint used in the acute exposure risk assessment was derived by dividing the LC₅₀ by a factor of two (2); to assess the risk for bees the acute contact LD₅₀ (µg/bee) was converted to LD₅₀ (kg ai/ha) by multiplying by 1.12 (Atkins, 1981).

*** Screening level EEC's in soil assume an application made to bare soil with a soil density of 1.5 mg/cm³ and even mixing through a 15 cm depth. Cumulative EECs for commercial application rates were estimated by adjusting the sum of the applications for dissipation between applications using a maximum soil DT₅₀ of 2 days for malathion, which is the most conservative value from the range of relevant values reported for soil aerobic biotransformation studies.

Risk quotients (RQ) shown in bold exceed the level of concern (RQ > 1).

Appendix XII Summary of screening level risk assessment of malathion to birds and mammals

Table 1 Summary of screening level risk assessment of malathion to birds

Bird weight	Effect / End point	Food guild / food item	Exposure		RQ	LOC exceeded	
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)			
Lowest malathion crop application rate - 425 g ai/ha.							
20g	Acute: 16.7 mg ai/kg bw/day	Insectivore (small insects)	84	21	1.3	Yes	
		Granivore (grain and seeds)	21	5	0.3	No	
		Frugivore (fruit)	42	11	0.7	No	
	Dietary: 15.6 mg ai/kg bw/day	Insectivore (small insects)	84	21	1.4	Yes	
		Granivore (grain and seeds)	21	5	0.3	No	
		Frugivore (fruit)	42	11	0.7	No	
	Reproduction: 11.7 mg ai/kg bw/day	Insectivore (small insects)	84	21	1.8	Yes	
		Granivore (grain and seeds)	21	5	0.4	No	
		Frugivore (fruit)	42	11	0.9	No	
	100g	Acute: 16.7 mg ai/kg bw/day	Insectivore (small insects)	84	17	1	Yes
			Granivore (grain and seeds)	21	4	0.2	No
			Frugivore (fruit)	42	8	0.5	No
Dietary: 15.6 mg ai/kg bw/day		Insectivore (small insects)	84	17	1.1	Yes	
		Granivore (grain and seeds)	21	4	0.3	No	
		Frugivore (fruit)	42	8	0.7	No	
Reproduction: 11.7 mg ai/kg bw/day		Insectivore (small insects)	84	17	1.4	Yes	
		Granivore (grain and seeds)	21	4	0.3	No	
		Frugivore (fruit)	42	8	0.7	No	
1000g		Acute: 16.7 mg ai/kg bw/day	Insectivore (large insects)	21	1	<0.1	No
			Granivore (grain and seeds)	21	1	<0.1	No
			Frugivore (fruit)	42	2	0.2	No
	Herbivore (short range grass)		300	17	1	Yes	
	Herbivore (leaves and leafy crops)		566	33	2	Yes	
	Herbicide (long grass)		183	11	0.6	No	
	Herbivore (forage crops)		278	16	0.9	No	
	Dietary: 15.6 mg ai/kg bw/day	Insectivore (large insects)	21	1	<0.1	No	
		granivore	21	1	<0.1	No	
		frugivore	42	2	0.1	No	
		Herbivore (short range grass)	300	17	1.1	Yes	
		Herbivore (leaves and leafy crops)	566	33	2.1	Yes	

Bird weight	Effect / Endpoint	Food guild / food item	Exposure		RQ	LOC exceeded
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)		
	Reproduction: 11.7 mg ai/kg bw/day	Herbicide (long grass)	183	11	0.7	No
		Herbivore (forage crops)	278	16	1.0	Yes
		Insectivore (large insects)	21	1	0.1	No
		granivore	21	1	0.1	No
		frugivore	42	2	0.2	No
		Herbivore (short range grass)	300	17	1.5	Yes
		Herbivore (leaves and leafy crops)	566	33	2.8	Yes
		Herbicide (long grass)	183	11	0.9	No
		Herbivore (forage crops)	278	16	1.4	Yes
medium malathion crop application rate (1 applications at 1376.5 g ai/ha, corn)						
20g	Acute: 16.7 mg ai/kg bw/day	Insectivore (small insects)	272	69	4.2	Yes
		granivore	68	17	1	Yes
		frugivore	136	35	2.1	Yes
	Dietary: 15.6 mg ai/kg bw/day	Insectivore (small insects)	272	69	4.4	Yes
		granivore	68	17	1.1	Yes
		frugivore	136	35	2.2	Yes
	Reproduction: 11.7 mg ai/kg bw/day	Insectivore (small insects)	272	69	5.9	Yes
		granivore	68	17	1.5	Yes
		frugivore	136	35	3	Yes
100g	Acute: 16.7 mg ai/kg bw/day	Insectivore (small insects)	272	54	3.2	Yes
		granivore	68	14	0.8	No
		frugivore	136	27	1.6	Yes
	Dietary: 15.6 mg ai/kg bw/day	Insectivore (small insects)	272	54	3.5	Yes
		granivore	68	14	0.9	No
		frugivore	136	27	1.7	Yes
	Reproduction: 11.7 mg ai/kg bw/day	Insectivore (small insects)	272	54	4.6	Yes
		granivore	68	14	1.1	Yes
		frugivore	136	27	2.3	Yes
1000g	Acute: 16.7 mg ai/kg bw/day	Insectivore (large insects)	68	4	0.2	No
		granivore	68	4	0.2	No
		frugivore	136	8	0.5	No
		Herbivore (short range grass)	972	56	3.4	Yes
		Herbivore (leaves and leafy crops)	1832	106	6.3	Yes
		Herbicide (long grass)	594	34	2.1	Yes
		Herbivore (forage crops)	899	52	3.1	Yes

Bird weight	Effect / Endpoint	Food guild / food item	Exposure		RQ	LOC exceeded
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)		
	Dietary: 15.6 mg ai/kg bw/day	Insectivore (large insects)	68	4	0.3	No
		granivore	68	4	0.3	No
		frugivore	136	8	0.5	No
		Herbivore (short range grass)	972	56	3.6	Yes
		Herbivore (leaves and leafy crops)	1832	106	6.8	Yes
		Herbicide (long grass)	594	34	2.2	Yes
		Herbivore (forage crops)	899	52	3.3	Yes
	Reproduction: 11.7 mg ai/kg bw/day	Insectivore (large insects)	68	4	0.3	No
		granivore	68	4	0.3	No
		frugivore	136	8	0.7	No
		Herbivore (short range grass)	972	56	4.8	Yes
		Herbivore (leaves and leafy crops)	1832	106	9.1	Yes
		Herbicide (long grass)	594	34	2.9	Yes
		Herbivore (forage crops)	899	52	4.5	Yes
highest cumulative malathion crop application rate (2 applications at 3952.5 g ai/ha)						
20g	Acute: 16.7 mg ai/kg bw/day	Insectivore (small insects)	1002	256	15	Yes
		granivore	251	64	3.8	Yes
		frugivore	501	128	7.7	Yes
	Dietary: 15.6 mg ai/kg bw/day	Insectivore (small insects)	1002	256	16	Yes
		granivore	251	64	4.1	Yes
		frugivore	501	128	8.1	Yes
	Reproduction: 11.7 mg ai/kg bw/day	insectivore	1002	256	22	Yes
		granivore	251	64	5.5	Yes
		frugivore	501	128	11	Yes
100g	Acute: 16.7 mg ai/kg bw/day	Insectivore (small insects)	1002	199	12	Yes
		granivore	251	50	3	Yes
		frugivore	501	100	6	Yes
	Dietary: 15.6 mg ai/kg bw/day	insectivore	1002	199	13	Yes
		granivore	251	50	3.2	Yes
		frugivore	501	100	6.4	Yes
	Reproduction: 11.7 mg ai/kg bw/day	Insectivore (small insects)	1002	199	17	Yes
		granivore	251	50	4.3	Yes
		frugivore	501	100	8.5	Yes
1000g	Acute: 16.7 mg ai/kg bw/day	Insectivore (large insects)	251	14	0.9	No
		granivore	251	14	0.9	No
		frugivore	501	29	1.7	Yes
		Herbivore (short range grass)	3583	208	12	Yes
		Herbivore (leaves and leafy crops)	6752	392	23	Yes
		Herbicide (long grass)	2187	127	7.6	Yes
		Herbivore (forage crops)	3314	193	12	Yes

Bird weight	Effect / Endpoint	Food guild / food item	Exposure		RQ	LOC exceeded
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)		
	Dietary: 15.6 mg ai/kg bw/day	Insectivore (large insects)	251	14	0.9	No
		granivore	251	14	0.9	No
		frugivore	501	29	1.9	Yes
		Herbivore (short range grass)	3583	208	13	Yes
		Herbivore (leaves and leafy crops)	6752	392	25	Yes
		Herbicide (long grass)	2187	127	8.1	Yes
		Herbivore (forage crops)	3314	193	12	Yes
		Reproduction: 11.7 mg ai/kg bow/day	Insectivore (large insects)	251	14	1.2
	granivore		251	14	1.2	Yes
	frugivore		501	29	2.5	Yes
	Herbivore (short range grass)		3583	208	18	Yes
	Herbivore (leaves and leafy crops)		6752	392	34	Yes
	Herbicide (long grass)		2187	127	11	Yes
		Herbivore (forage crops)	3314	193	16	Yes

Table 2 Summary of screening level risk assessment of malathion to mammals

Mammal weight	Effect / Endpoint	Food guild / food item	Exposure		RQ	LOC exceeded
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)		
Lowest malathion crop application rate - 425 g ai/ha						
15g	Acute: 158 mg ai/kg bw/day	Insectivore (small insects)	84	12	<0.1	No
		Granivore (grain and seeds)	21	3	<0.1	No
		Frugivore (fruit)	42	6	<0.1	No
	Reproduction: 394 mg ai/kg bw/day	Insectivore (small insects)	84	12	<0.1	No
		Granivore (grain and seeds)	21	3	<0.1	No
		Frugivore (fruit)	42	6	<0.1	No
35g	Acute: 158 mg ai/kg bw/day	Insectivore (small insects)	84	11	<0.1	No
		Granivore (grain and seeds)	21	3	<0.1	No
		Frugivore (fruit)	42	5	<0.1	No
		Herbivore (short range grass)	300	39	0.2	No
		Herbivore (leaves and leafy crops)	566	73	0.5	No
		Herbicide (long grass)	183	24	0.2	No
		Herbivore (forage crops)	278	36	0.2	No
	Reproduction: 394 mg ai/kg bw/day	Insectivore (small insects)	84	11	<0.1	No
		Granivore (grain and seeds)	21	3	<0.1	No
		Frugivore (fruit)	42	5	<0.1	No
		Herbivore (short range grass)	300	39	<0.1	No
		Herbivore (leaves and leafy crops)	566	73	0.2	No
		Herbicide (long grass)	183	24	<0.1	No
		Herbivore (forage crops)	278	36	<0.1	No
1000g	Acute: 158 mg ai/kg bw/day	Insectivore (large insects)	21	1	<0.1	No
		Granivore (grain and seeds)	21	1	<0.1	No
		Frugivore (fruit)	42	3	<0.1	No
		Herbivore (short range grass)	300	21	0.1	No
		Herbivore (leaves and leafy crops)	566	39	0.2	No
		Herbicide (long grass)	183	13	0.1	No
		Herbivore (forage crops)	278	19	0.1	No
	Reproduction: 394 mg ai/kg bw/day	Insectivore (large insects)	21	1	<0.1	No
		granivore	21	1	<0.1	No
		frugivore	42	3	<0.1	No

Mammal weight	Effect / Endpoint	Food guild / food item	Exposure		RQ	LOC exceeded
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)		
		Herbivore (short range grass)	300	21	<0.1	No
		Herbivore (leaves and leafy crops)	566	39	<0.1	No
		Herbicide (long grass)	183	13	<0.1	No
		Herbivore (forage crops)	278	19	<0.1	No
Medium malathion crop application rate (1 applications at 1376.5 g ai/ha, corn)						
15g	Acute: 158 mg ai/kg bw/day	Insectivore (small insects)	272	40	0.2	No
		granivore	68	10	<0.1	No
		frugivore	136	20	0.1	No
	Reproduction: 394 mg ai/kg bw/day	Insectivore (small insects)	272	40	0.1	No
		granivore	68	10	<0.1	No
		frugivore	136	20	<0.1	No
35g	Acute: 158 mg ai/kg bw/day	Insectivore (small insects)	272	35	0.2	No
		granivore	68	9	<0.1	No
		frugivore	136	17	0.1	No
		Herbivore (short range grass)	972	125	0.8	No
		Herbivore (leaves and leafy crops)	1832	236	1.5	Yes
		Herbicide (long grass)	594	76	0.5	No
		Herbivore (forage crops)	899	116	0.7	No
	Reproduction: 394 mg ai/kg bw/day	Insectivore (small insects)	272	35	<0.1	No
		granivore	68	9	<0.1	No
		frugivore	136	17	<0.1	No
		Herbivore (short range grass)	972	125	0.3	No
		Herbivore (leaves and leafy crops)	1832	236	0.6	No
		Herbicide (long grass)	594	76	0.2	No
		Herbivore (forage crops)	899	116	0.3	No
1000g	Acute: 158 mg ai/kg bw/day	Insectivore (large insects)	68	5	<0.1	No
		granivore	68	5	<0.1	No
		frugivore	136	9	<0.1	No
		Herbivore (short range grass)	972	67	0.4	No
		Herbivore (leaves and leafy crops)	1832	126	0.8	No
		Herbicide (long grass)	594	41	0.3	No
		Herbivore (forage crops)	899	62	0.4	No

Mammal weight	Effect / Endpoint	Food guild / food item	Exposure		RQ	LOC exceeded
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)		
	Reproduction: 394 mg ai/kg bw/day	Insectivore (large insects)	68	5	<0.1	No
		granivore	68	5	<0.1	No
		frugivore	136	9	<0.1	No
		Herbivore (short range grass)	972	67	0.2	No
		Herbivore (leaves and leafy crops)	1832	126	0.3	No
		Herbicide (long grass)	594	41	0.1	No
		Herbivore (forage crops)	899	62	0.2	No
Highest cumulative malathion crop application rate (2 applications at 3952.5 g ai/ha)						
15g	Acute: 158mg ai/kg bw/day	Insectivore (small insects)	1002	147	0.9	No
		granivore	251	37	0.2	No
		frugivore	501	74	0.5	No
	Reproduction: 394 mg ai/kg bw/day	insectivore	1002	147	0.4	No
		granivore	251	37	<0.1	No
		frugivore	501	74	0.2	No
35g	Acute: 158mg ai/kg bw/day	Insectivore (small insects)	1002	129	0.8	No
		granivore	251	32	0.2	No
		frugivore	501	64	0.4	No
		Herbivore (short range grass)	3583	461	2.9	Yes
		Herbivore (leaves and leafy crops)	6752	868	5.5	Yes
		Herbicide (long grass)	2187	281	1.8	Yes
		Herbivore (forage crops)	3315	426	2.7	Yes
	Reproduction: 394 mg ai/kg bw/day	Insectivore (small insects)	1002	129	0.3	No
		granivore	251	32	<0.1	No
		frugivore	501	64	0.2	No
		Herbivore (short range grass)	3583	461	1.2	Yes
		Herbivore (leaves and leafy crops)	6752	868	2.2	Yes
		Herbicide (long grass)	2187	281	0.7	No
		Herbivore (forage crops)	3315	426	1.1	Yes
1000g	Acute: 158 mg ai/kg bw/day	Insectivore (large insects)	251	17	0.1	No
		granivore	251	17	0.1	No
		frugivore	501	34	0.2	No
		Herbivore (short range grass)	3583	246	1.6	Yes
		Herbivore (leaves and leafy crops)	6752	464	2.9	Yes
		Herbicide (long grass)	2187	150	1	No
		Herbivore (forage crops)	3315	228	1.4	Yes

Mammal weight	Effect / Endpoint	Food guild / food item	Exposure		RQ	LOC exceeded
			EEC (mg ai/kg diet)	EDE (mg ai/kg bw)		
	Reproduction: 394 mg ai/kg bw/day	Insectivore (large insects)	251	17	<0.1	No
		granivore	251	17	<0.1	No
		frugivore	501	34	<0.1	No
		Herbivore (short range grass)	3583	246	0.6	No
		Herbivore (leaves and leafy crops)	6752	464	1.2	Yes
		Herbicide (long grass)	2187	150	0.4	No
		Herbivore (forage crops)	3315	228	0.6	No

Appendix XIII Refined avian on-field risk assessment using mean residue values

Bird weight	Effect*	Food guild / item	Exposure		RQ	LOC exceeded	% diet to reach LOC	# of days residues above LOC	
			EEC	EDE					
lowest single crop application rate, 425 g ai/ha.									
20g	Acute:	Insectivores (small insects)	47	12	0.1	No	-	-	
	87.6 mg ai/kg bw/day								
	Dietary:								
	111.7 mg ai/kg bw/day								
100g	Acute:	Insectivores (small insects)	47	9	0.1	No	-	-	
	87.6 mg ai/kg bw/day								
	Dietary:								
	111.7 mg ai/kg bw/day								
1000g	Acute:	Herbivore (short range grass)	107	6	<0.1	No	-	-	
	Dietary:	Herbivore (leaves and leafy crops)	187	11	0.1	No	-	-	
		Herbivore (forage crops)	92	5	<0.1	No	-	-	
		Herbivore (short range grass)	107	6	<0.1	No	-	-	
		Herbivore (leaves and leafy crops)	187	11	0.1	No	-	-	
		Herbivore (forage crops)	92	5	<0.1	No	-	-	
		Reproduction:	Herbivore (short range grass)	107	6	0.2	No	-	-
	27.8 mg ai/kg bw/day	Herbivore (leaves and leafy crops)	187	11	0.4	No	-	-	
		Herbivore (forage crops)	92	5	0.1	No	-	-	
		medium single crop application rate, 1376.5 g ai/ha							
		20g	Acute:	Insectivores (small insects)	152	39	0.4	No	-
	87.6 mg ai/kg bw/day								
Dietary:									
111.7 mg ai/kg bw/day									
Reproduction:	Granivore		32	8	1.4	Yes	72	3	
27.8 mg ai/kg bw/day									
	frugivore	65	17	0.6	No	-	-		

Bird weight	Effect*	Food guild / item	Exposure		RQ	LOC exceeded	% diet to reach LOC	# of days residues above LOC
			EEC	EDE				
100g	Acute:				0.3	No	-	-
	87.6 mg ai/kg bw/day							
	Dietary:	Insectivores (small insects)	152	30	0.3	No	-	-
	111.7 mg ai/kg bw/day							
100g	Reproduction:				1.1	Yes	92	1
	27.8 mg ai/kg bw/day							
		Frugivore	65	13	0.5	No	-	-
1000g	Acute:	Herbivore (short range grass)	345	20	0.2	No	-	-
	87.6 mg ai/kg bw/day	Herbivore (leaves and leafy crops)	606	35	0.4	No	-	-
		Herbivore (long grass)	194	11	0.1	No	-	-
		Herbivore (forage crops)	397	17	0.2	No	-	-
	Dietary:	Herbivore (short range grass)	345	20	0.2	No	-	-
	111.7 mg ai/kg bw/day	Herbivore (leaves and leafy crops)	606	35	0.3	No	-	-
		Herbivore (long grass)	194	11	0.1	No	-	-
		Herbivore (forage crops)	397	17	0.2	No	-	-
	Reproduction:	Herbivore (short range grass)	345	20	0.7	No	-	-
	27.8 mg ai/kg bw/day	Herbivore (leaves and leafy crops)	606	35	1.2	Yes	79	3
		Herbivore (long grass)	194	11	0.4	No	-	-
		Herbivore (forage crops)	397	17	0.6	No	-	-
highest cumulative crop application rate, 3952 g ai/ha (2 applications, 10 day interval)								
20g	Acute:	Insectivores (small insects)	559	143	1.6	Yes	61	6
	87.6 mg ai/kg bw/day	Granivore	119	30	0.3	No	-	-
		frugivore	239	60	0.7	No	-	-
	Dietary:	Insectivores (small insects)	559	143	1.3	Yes	78	2
	111.7 mg ai/kg bw/day	Granivore	119	30	0.3	No	-	-
		frugivore	239	60	0.5	No	-	-
	Reproduction:	Insectivores (small insects)	559	143	5.1	Yes	20	23
	27.8 mg ai/kg bw/day	Granivore	119	30	1.1	Yes	91	1

Bird weight	Effect ^a	Food guild / item	Exposure		RQ	LOC exceeded	% diet to reach LOC	# of days residues above LOC
			EEC	EDE				
		Frugivore	239	60	2.2	Yes	46	12
100g	Acute: 87.6 mg ai/kg bw/day	Insectivores (small insects)	559	111	1.3	Yes	79	2
		Granivore	120	24	0.3	No	-	-
		Frugivore	239	48	0.5	No	-	-
	Dietary: 111.7 mg ai/kg bw/day	Insectivores (small insects)	559	111	0.9	No	-	-
		Granivore	120	24	0.2	No	-	-
		Frugivore	239	48	0.4	No	-	-
	Reproduction: 27.8 mg ai/kg bw/day	Insectivores (small insects)	559	111	4.0	Yes	25	22
		Granivore	120	24	0.9	No	-	-
		Frugivore	239	48	1.7	Yes	58	8
1000g	Acute: 87.6 mg ai/kg bw/day	Frugivore	239	14	0.2	No	-	-
		Herbivore (short range grass)	1272	74	0.8	No	-	-
		Herbivore (leaves and leafy crops)	2232	130	1.5	Yes	68	7
		Herbivore (long grass)	714	41	0.5	No	-	-
		Herbivore (forage crops)	1096	64	0.7	No	-	-
	Dietary: 111.7 mg ai/kg bw/day	Frugivore	239	14	0.1	No	-	-
		Herbivore (short range grass)	1272	74	0.7	No	-	-
		Herbivore (leaves and leafy crops)	2232	130	1.2	Yes	86	3
		Herbivore (long grass)	714	41	0.4	No	-	-
		Herbivore (forage crops)	1096	64	0.6	No	-	-
	Reproduction: 27.8 mg ai/kg bw/day	Frugivore	239	14	0.5	No	-	-
		Herbivore (short range grass)	1272	74	2.7	Yes	38	14
		Herbivore (leaves and leafy crops)	2232	130	4.7	Yes	21	24
		Herbivore (long grass)	714	41	1.5	Yes	67	6
		Herbivore (forage crops)	1096	64	2.3	Yes	44	12

a - Both acute and dietary endpoints are based on the HD_{05} (5th percentile of the species distribution for the LD_{05} at 50% confidence intervals). The reproductive endpoint represents the geometric mean of two available toxicity endpoints (NOAEL for the northern bobwhite quail and mallard duck); the geometric mean of the NOAELs provides an endpoint representative for 'average sensitivity' species.

RQs in bold exceed the level of concern.

Appendix XIV Refined avian off-field risk assessment using mean residue values

Bird weight	Effect	Food guild / item	Exposure		RQ	LOC exceeded	% diet to reach LOC	# of days residues above LOC
			EEC	EDE				
Maximum cumulative field sprayer application - 1376 g ai/ha x4, 3 day intervals (drift deposition based on coarse spray droplet size, 3%)								
20g	Reproduction: 27.8 mg ai/kg bw/day	Insectivore (small insects)	11	3	0.1	No	-	-
100g		Insectivore (small insects)	11	2	<0.1	No	-	-
1000g		Herbivore (leaves and leafy crops)	45	3	0.1	No	-	-
Maximum cumulative aerial application - 1376.5 g ai/ha x2, 14 day interval (drift deposition based on coarse spray droplet size, 17%)								
20g	Reproduction: 27.8 mg ai/kg bw/day	Insectivore (small insects)	30	8	0.3	No	-	-
100g		Insectivore (small insects)	30	6	0.2	No	-	-
1000g		Herbivore (leaves and leafy crops)	121	7	0.3	No	-	-
Maximum cumulative early airblast application - 3952.5 x2, 10 day interval (74% drift deposition)								
20g	Acute: 87.6 mg ai/kg bw/day Dietary: 111.7 mg ai/kg bw/day Reproduction: 27.8 mg ai/kg bw/day	Insectivore (small insects)	414	105	1.2	Yes	83	2
		Insectivore (small insects)	414	105	0.9	No	-	-
		Insectivore (small insects)	414	105	3.8	Yes	26	20
		Carnivore	88	23	0.8	No	-	-
		Frugivore	177	45	1.6	Yes	62	6
100g	Acute: 87.6 mg ai/kg bw/day Reproduction: 27.8 mg ai/kg bw/day	Insectivore (small insects)	414	82	0.9	No	-	-
		Insectivore (small insects)	414	82	3.0	Yes	34	16
		Frugivore	177	45	1.6	Yes	79	2
1000g	Acute: 87.6 mg ai/kg bw/day Dietary: 111.7 mg ai/kg bw/day Reproduction: 27.8 mg ai/kg bw/day	Herbivore (leaves and leafy crops)	1652	96	1.1	Yes	91	2
		Herbivore (leaves and leafy crops)	1652	96	0.9	No	-	-
		Herbivore (leaves and leafy crops)	1652	96	3.5	Yes	29	19
		Herbivore (long grass)	529	31	1.1	Yes	91	1
		Herbivore (short grass)	942	55	2.0	Yes	51	10
		Herbivore (forage crops)	811	47	1.7	Yes	59	8

a - Both acute and dietary endpoints are based on the IID₅ (5th percentile of the species distribution for the I.D.₅₀ at 50% confidence intervals). The reproductive endpoint represents the geometric mean of two available toxicity endpoints (NOEL for the northern bobwhite quail and mallard duck); the geometric mean of the NOELs provides an endpoint representative for 'average sensitivity' species.

* - Value represents the cumulative number of days that residues are greater than the LOC resulting from multiple application. Value does not include days between applications in which residues fall below the LOC.

RQs in bold exceed the level of concern.

Appendix XV Refined mammalian on-field risk assessment using mean residue values

Mammal weight	Effect*	Food guild / item	Exposure		RQ	LOC exceeded	% diet to reach LOC	# of days residues above LOC
			EEC	EDE				
medium single crop application rate, 1376.5g ai/ha								
35 g	Acute: 356 mg ai/kg bw/day	Herbivore (leaves and leafy crops)	606	78	0.2	No	-	-
highest cumulative crop application rate, 3952.5 g ai/ha (2 applications, 10 day interval)								
35 g	Acute: 356 mg ai/kg bw/day	Herbivore (short range grass)	1272	164	0.5	No	-	-
		Herbivore (leaves and leafy crops)	2232	287	0.8	No	-	-
		Herbicide (long grass)	714	92	0.3	No	-	-
		Herbivore (forage crops)	1096	141	0.4	No	-	-
	Reproduction: 394 mg ai/kg bw/day	Herbivore (short range grass)	1272	164	0.4	No	-	-
		Herbivore (leaves and leafy crops)	2232	287	0.7	No	-	-
		Herbivore (forage crops)	1096	141	0.4	No	-	-
1000g	Acute: 356 mg ai/kg bw/day	Herbivore (short range grass)	1272	87	0.2	No	-	-
		Herbivore (leaves and leafy crops)	2232	153	0.4	No	-	-
		Herbivore (forage crops)	1096	75	0.2	No	-	-
	Reproduction: 394 mg ai/kg bw/day	Herbivore (leaves and leafy crops)	2232	153	0.4	No	-	-

a- The acute endpoint represents the geometric mean of two available toxicity endpoints for the Wistar rat (LD₅₀ = 1580 and 8000 mg ai/kg bw/day). The geometric mean of the LD₅₀s provides an endpoint representative for 'average sensitivity' species. To address uncertainties such as differences in species sensitivity as well as varying protection levels (for example, community, population, individual), the geometric mean was further divided by a factor of 10.

RQs in bold exceed the level of concern.

Appendix XVI Summary of screening level risk assessment of malathion to aquatic organisms

Organism	Exposure	Species	Endpoint reported (µg ai/L.)	Endpoint for RA* (µg ai/L.)	Use Rate** (g ai/ha)	EEC*** (µg ai/L.)	RQ	LOC Exceeded
Freshwater Species								
Invertebrate	Acute	Amphipod (<i>Gammarus fasciatus</i>)	LC ₅₀ = 0.50	0.25	425	53	212	Yes
					3952.5 (2x)	840	3360	Yes
	Chronic	Daphnid (<i>Daphnia magna</i>)	NOEC = 0.06	0.06	425	53	883	Yes
					3952.5 (2x)	840	14000	Yes
Fish	Acute	Rainbow trout (<i>O. mykiss</i>)	LC ₅₀ = 4	0.4	425	53	133	Yes
					3952.5 (2x)	840	2100	Yes
	Chronic	Bluegill sunfish (<i>Lepomis macrochirus</i>)	NOEC = 7.4	7.4	425	53	7.2	Yes
					3952.5 (2x)	840	114	Yes
Amphibian	Acute	Western chorus frog (<i>Pseudacris triseriata</i>), tadpole stage	LC ₅₀ = 200	20	425	280	14	Yes
					3952.5 (2x)	4460	223	Yes
	Chronic	Surrogate fish (Bluegill sunfish - <i>Lepomis macrochirus</i>)	NOEC = 7.4	7.4	425	280	38	Yes
					3952.5 (2x)	4460	603	Yes
Plant	No data available							
Estuarine and Marine Species								
Invertebrate	Acute	Mysid shrimp (<i>M. bahia</i>)	LC ₅₀ = 2.2	1.1	425	53	48	Yes
					3952.5 (2x)	840	764	Yes
Fish	Acute	Sheepshead minnow (<i>C. variegatus</i>)	LC ₅₀ = 33	3.3	425	53	16	Yes
					3952.5 (2x)	840	255	Yes
	Chronic – 140d		NOEC < 9 - 18	9	425	53	5.8	Yes
					3952.5 (2x)	840	93	Yes
Plant	No data available							

* Endpoints used in the acute exposure risk assessment (RA) are derived by dividing the EC₅₀ or LC₅₀ from the appropriate laboratory study by a factor of two (2) for aquatic invertebrates and plants, and by a factor of ten (10) for fish and amphibians.

** Application rate represents the minimum and maximum (cumulative) applications rates as indicated on labels.

*** EEC based on a 15 cm water body depth for amphibians and a 80 cm water depth for all other aquatic organisms. Cumulative EECs for commercial application rates were estimated by adjusting the sum of the applications for dissipation between applications using a maximum aquatic DT₅₀ of 19 days for malathion, which is the most conservative value from the range of relevant values reported for aerobic aquatic biotransformation studies.

Bolded values indicates an exceedence of the level of concern (RQ = 1).

Appendix XVII Spray Drift Assessment of Malathion to Aquatic Organisms

Organism	Exposure	Species	Endpoint reported ($\mu\text{g ai/L}$)	Endpoint for RA ¹ ($\mu\text{g ai/L}$)	Use Scenario	Application rate ² (g ai/ha)	EEC ($\mu\text{g ai/L}$) ³	RQ	LOC exceeded
Freshwater Invertebrate	Acute	18 invertebrate: planktonic (4), benthic (5), aquatic insects (7) and mollusks (2)	HD ₅ = 0.13	0.13	field sprayer	527	2	15	Yes
						1376.5 (4x)	15	115	Yes
					airblast (early)	625	57	438	Yes
						3952.5 (2x)	523	4023	Yes
					airblast (late)	625	46	354	Yes
						3952.5 (2x)	417	3208	Yes
					aerial	425	9	69	Yes
	Chronic	<i>Daphid (D. magna)</i>	NOEC = 0.06	0.06		1376.5 (2x)	38	292	Yes
					field sprayer	527	2	33	Yes
						1376.5 (4x)	15	250	Yes
					airblast (early)	625	57	950	Yes
						3952.5 (2x)	523	8717	Yes
					airblast (late)	625	46	767	Yes
						3952.5 (2x)	417	6950	Yes
Freshwater fish	Acute	17 species of freshwater fish	HD ₅ = 7.5	7.5		1376.5 (2x)	38	633	Yes
					field sprayer	527	2	0.3	No
						1376.5 (4x)	15	2	Yes
					airblast (early)	625	57	7.6	Yes
						3952.5 (2x)	523	70	Yes
					airblast (late)	625	46	6.1	Yes
						3952.5 (2x)	417	56	Yes
	Chronic	5 species of freshwater fish	HD ₅ = 2.0	2		1376.5 (2x)	38	5.1	Yes
					field sprayer	527	2	1	Yes
						1376.5 (4x)	15	7.5	Yes
					airblast (early)	625	57	29	Yes
						3952.5 (2x)	523	262	Yes
					airblast (late)	625	46	23	Yes
						3952.5 (2x)	417	209	Yes
Amphibian	Acute	Western chorus frog (<i>Pseudacris triseriata</i>), tadpole stage	LC ₅₀ = 200	20		1376.5 (2x)	38	19	Yes
					field sprayer	527	11	0.6	No
						1376.5 (4x)	78	3.9	Yes
					airblast (early)	625	308	15	Yes
						3952.5 (2x)	2792	140	Yes
					airblast (late)	625	246	12	Yes
						3952.5 (2x)	2226	111	Yes
	Chronic	Surrogate fish (5 species of freshwater fish)	HD ₅ = 2.0	2		1376.5 (2x)	204	10	Yes
					field sprayer	527	11	5.5	Yes
						1376.5 (4x)	78	39	Yes
					airblast (early)	625	308	154	Yes
						3952.5 (2x)	2792	1396	Yes
					airblast (late)	625	246	123	Yes
						3952.5 (2x)	2226	1113	Yes
Plant Marine / estuarine invertebrate	Acute	<i>Mysid shrimp (M. bahia)</i>	LC ₅₀ = 2.2	1.1	No data available.				
					field sprayer	527	2	1.8	Yes
						1376.5 (4x)	15	14	Yes
					airblast (early)	625	57	52	Yes

Organism	Exposure	Species	Endpoint reported (µg ai/L)	Endpoint for RA ¹ (µg ai/L)	Use Scenario	Application rate ² (g ai/ha)	EEC (µg ai/L.) ³	RQ	LOC exceeded
Marine /estuarine fish	Acute	5 species of marine fish	HD ₅ = 31.3	31.3	airblast (late)	3952.5 (2x)	523	475	Yes
						625	46	42	Yes
						3952.5 (2x)	417	379	Yes
					airblast	425	9	8.1	Yes
						1376.5 (4x)	38	35	Yes
					field sprayer	527	2	<0.1	No
						1376.5 (4x)	15	0.5	No
					airblast (early)	625	57	1.8	Yes
						3952.5 (2x)	523	17	Yes
					airblast (late)	625	46	1.5	Yes
	Chronic	Sheepshead minnow (<i>C. variegatus</i>)	NOEC <9 - 18	9		3952.5 (2x)	417	13	Yes
					airblast	425	9	0.3	No
						1376.5 (2x)	38	1.2	Yes
					field sprayer	527	2	0.2	No
						1376.5 (4x)	15	1.6	Yes
					airblast (early)	625	57	6.3	Yes
						3952.5 (2x)	523	58	Yes
					airblast (late)	625	46	5.1	Yes
						3952.5 (2x)	417	46	Yes
					airblast	425	9	1	Yes
						1376.5 (2x)	38	4.2	Yes
Plant	No data available								

1- Endpoints used in the acute exposure risk assessment (RA) are derived by dividing the EC₅₀, LC₅₀ from the appropriate laboratory study by a factor of two (2) for aquatic invertebrates and plants, and by a factor of ten (10) for fish and amphibians. The HD₅ is the 5th percentile of the species sensitivity distribution for the LC₅₀ or NOEC at 50% confidence intervals.

2 - The assessment of potential risk from drift was assessed for the minimum single and maximum cumulative application rates as listed on the labels specific to each of the three application methods.

3 - The maximum amount of spray that is expected to drift 1m downwind from the application site during spraying using field sprayer and aerial application methods was determined based on a coarse spray droplet size, 3% and 17%, respectively. The maximum amount of spray that is expected to drift 1m downwind from the application site during spraying using airblast application is 74%. Cumulative EECs for commercial application rates were estimated by adjusting the sum of the applications for dissipation between applications using the 80th percentile of aerobic aquatic biotransformation half-lives (8.25 days).

Bolded values indicates an exceedence of the level of concern (RQ = 1).

Appendix XVIII Refined risk assessment of malathion for aquatic organisms from predicted run-off

Organism	Exposure	Species	Endpoint reported (µg ai/L)	Endpoint for RA* (µg ai/L)	Use Rate** (g ai/ha)	EEC*** (µg ai/L)	RQ	LOC exceeded
Freshwater Species								
Invertebrate ¹	Acute	18 invertebrate: planktonic (4), benthic (5), aquatic insects (7) and mollusks (2)	HC5 = 0.13	0.13	425	0.51	3.9	Yes
					3952.5 (2x)	9.82	76	Yes
Fish ²	Chronic	Daphnid (<i>D. magna</i>)	NOEC = 0.06	0.06	425	0.14	2.3	Yes
	Acute	17 species of freshwater fish	HC5 = 7.5	7.5	3952.5 (2x)	2.96	49	Yes
					425	0.51	<0.1	No
					3952.5 (2x)	9.82	1.3	Yes
Amphibian ³	Chronic	5 species of freshwater fish	HC5 = 2.0	2	425	0.04	<0.1	No
					3952.5 (2x)	0.77	0.4	No
	Acute	Western chorus frog(<i>Pseudacris triseriata</i>), tadpole stage	LC ₅₀ = 200	20	425	2.7	0.1	No
					3952.5 (2x)	52.05	2.6	Yes
Plant	Chronic 79 days	Surrogate fish (5 species of freshwater fish)	HC5 = 2.0	2	425	0.58	0.3	No
					3952.5 (2x)	12.32	6.2	Yes
					No data available			
Estuarine and Marine Species								
Invertebrate	Acute	Mysid shrimp (<i>M. bahia</i>)	LC ₅₀ = 2.2	1.1	425	0.51	0.5	No
					3952.5 (2x)	9.82	8.9	Yes
Fish ²	Acute	5 species of freshwater fish	HC ₅ = 31.3	31.3	425	0.51	<0.1	No
					3952.5 (2x)	9.82	0.3	No
	Chronic 140-day	Sheepshead minnow (<i>C. variegatus</i>)	NOEC < 9 - 18	9	425	0.04	<0.1	No
					3952.5 (2x)	0.77	<0.1	No
Plant	No data available							

* Endpoints used in the acute exposure risk assessment (RA) are derived by dividing the EC₅₀, LC₅₀ from the appropriate laboratory study by a factor of two (2) for aquatic invertebrates and plants, and by a factor of ten (10) for fish and amphibians.

The HC₅ is the 5th percentile of the species sensitivity distribution for the LC₅₀ or NOEC at 50% confidence intervals.

** Application rate represents the minimum and maximum (cumulative) applications rates as indicated on labels.

*** EEC based on a 15 cm water body depth for amphibians and a 80 cm water depth for all other aquatic organisms.

¹ Chronic EEC values represents 90th percentile of the 21 day average for 80 cm deep water body.

² Chronic EEC values represent 90th percentile of the 90 day average for 80 cm deep water body.

³ Chronic EEC values represent 90th percentile of the 21 day average for 15 cm deep water body.

Bolded values indicates an exceedence of the level of concern (RQ = 1).

Appendix XIX Refined risk assessment of malathion to aquatic organisms using Canadian monitoring data

Organism	Exposure	Species	Endpoint reported (µg ai/L)	Endpoint for RA* (µg ai/L)	EEC** (µg ai/L)	RQ	LOC exceeded
Freshwater Species							
Invertebrate	Acute	18 invertebrate: planktonic (4), benthic (5), aquatic insects (7) and mollusks (2)	HC5 = 0.13	0.13	1.6	12	Yes
Fish	Chronic	Daphnid (<i>D. magna</i>)	NOEC = 0.06	0.06	0.1	1.7	Yes
	Acute	17 species of freshwater fish	HC5 = 7.5	0.75	1.6	0.2	No
	Chronic (300 day)	5 species of freshwater fish	HC5 = 2.0	2	0.1	<0.1	No
Amphibian	Acute	Western chorus frog (<i>Pseudacris triseriata</i>), tadpole stage	LC ₅₀ = 200	20	1.6	<0.1	No
	Chronic	Surrogate fish (5 species of freshwater fish)	HC5 = 2.0	2	0.1	<0.1	No
Plant	No data available						
Estuarine and Marine Species							
Invertebrate	Acute	Mysid shrimp (<i>M. bahia</i>)	LC ₅₀ = 2.2	1.1	1.6	1.5	Yes
Fish	Acute	5 species of freshwater fish	HC5 = 31.3	31.3	1.6	<0.1	No
	Chronic 140 day	Sheepshead minnow (<i>C. variegatus</i>)	NOEC < 9 -18	9	0.1	<0.1	No
Plant	No data available						

*Endpoints used in the acute exposure risk assessment (RA) are derived by dividing the EC₅₀, LC₅₀ from the appropriate laboratory study by a factor of two (2) for aquatic invertebrates and plants, and by a factor of ten (10) for fish and amphibians.

The HC₅ is the 5th percentile of the species sensitivity distribution for the LC₅₀ or NOEC at 50% confidence intervals.

** EEC based on monitoring data (see Appendix XX Table 2).

Bolded values indicates an exceedence of the level of concern (RQ = 1).

Appendix XX Water Modelling and Monitoring for Use in Drinking Water Risk Assessment

Modelling Results

Estimated environmental concentrations (EECs) of malathion in potential drinking water sources (groundwater and surface water) were estimated using computer simulation models. An overview of how the EECs are estimated is provided in the PMRA's Science Policy Notice SPN2004-01, *Estimating the Water Component of a Dietary Exposure Assessment*. EECs of malathion in groundwater were calculated using the LEACHM model to simulate leaching through a layered soil profile over a 50-year period. EECs of malathion in surface water were calculated using the PRZM/EXAMS models, which simulate pesticide runoff from a treated field into an adjacent water body and the fate of a pesticide within that water body. Pesticide concentrations in surface water were estimated in two types of vulnerable drinking water sources, a small reservoir and a prairie dugout.

Screening level (Level 1) EECs for drinking water sources were not generated, as there was evidence suggesting that Level 2 EECs would be required for malathion in drinking water sources. The following use patterns were modelled at Level 2: apples (2 airblast applications at 3.952 kg ai/ha at 10-day intervals; corn (5 ground applications at 1.3765 kg ai/ha at 3-day intervals); and alfalfa (4 ground or aerial applications at 1.3765 kg ai/ha, at 14-day intervals). As uses on orchard crops are expected to be minimal in the Prairies, the dugout scenario was not considered relevant to the apple use pattern. Thus, EECs related to the use pattern for apples are only reported for reservoirs.

Table 1 provides the Level 2 EECs for malathion in potential sources of drinking water. For each of the use patterns modelled, the application date and method producing the largest EEC in relevant drinking water sources are presented.

Table 1 Level 2 estimated environmental concentrations of malathion in potential drinking water sources

Compound	Groundwater EEC ($\mu\text{g ai/L}$)		Surface Water EEC ($\mu\text{g ai/L}$)			
			Reservoir		Dugout	
	Daily ¹	Yearly ²	Daily ³	Yearly ⁴	Daily ³	Yearly ⁴
Orchard rate (3952 g/ha x 2 at 10 day intervals)						
malathion	0	0	14.35	0.35	Not relevant ⁵	Not relevant ⁵
Crop rate (corn: 1376.5 g/ha x 5 applications at 3 day intervals)						
malathion	0	0	12.02	0.22	14.52	0.34
Crop rate (alfalfa: 1376.5 g/ha x 4 at 14 day intervals)						
malathion	0	0	17.96	1.01	12.23	0.59

Notes:

- 1 90th percentile of daily average concentrations
- 2 90th percentile of yearly average concentrations
- 3 90th percentile of yearly peak concentrations
- 4 90th percentile of yearly average concentrations
- 5 EECs for dugouts based on the use pattern for orchards were not provided as an orchard scenario was not considered relevant to the Prairies.

Water Monitoring Data

A search for malathion water monitoring data in Canada resulted in a number of samples with detections being reported. The Federal Provincial and Territorial representatives from all of the provinces and territories in Canada were contacted, requesting water monitoring data for the organophosphates that are currently under re-evaluation. In addition, requests were submitted to Environment Canada, the Department of Fisheries and Oceans and the drinking water subcommittee through Health Canada. A response was received by all provinces and territories indicating that either monitoring data were not available or the available data were submitted.

US databases were searched for detections of malathion. Data on residues present in water samples taken in the US are important to consider in the Canadian drinking water assessment given the extensive monitoring programs that exist in the US. Runoff events, local use patterns, site specific hydrogeology as well as testing and reporting methods are probably more important influences on residue data rather than Northern versus Southern climate. As for the climate, if temperatures are cooler, residues may break down more slowly, on the other hand if temperatures are warmer, growing seasons may be longer and applications may be more numerous and frequent. Data were available from the US Geological Survey National Water Quality Assessment program (NAWQA) for both groundwater and surface water, and from the Six Year Review of National Drinking Water Regulations, as part of the US National Contaminant Occurrence Database (NCOD). Data from Canadian and US water monitoring studies for malathion and malaoxon are summarized in Table 2 and 3, respectively.

An important limitation of the monitoring data set is that, in many cases, the data were not accompanied with use data for malathion. For instance, the application rate applied, when the application occurred and weather conditions prior to sampling were not known or reported. Without this information, it is difficult to conclude if non-detects were a result of non-transport or more simply a result of inappropriate timing of sampling. In addition, because concentrations vary in time and space, sampling is unlikely to capture the absolute maximum concentration that would be observed.

Despite the uncertainties associated with the monitoring data, this data contains a large number of samples collected and analyzed over a number of years, and was considered in the assessment.

Malaoxon Formation as a Result of Chlorination in Treatment Plants

EAD and HED have jointly examined available information with respect to the transformation of malathion to malaoxon during treatment of drinking water supplies. The evidence indicates that the formation of malathion occurs as a result of oxidation during the chlorination process in water treatment. It is worth noting that the concern for malaoxon formation is primarily restricted to surface water. Public drinking water supplies from groundwater sources are often chlorinated, but they are usually deep wells which are less susceptible to contamination by malaoxon. Private wells, which tend to be shallow, are more vulnerable to contamination, however, chlorination is seldom used to sanitize private well water.

Based on the available, limited information, the PMRA has assumed 100 percent transformation of malathion to malaoxon, which is consistent with the approach taken by the US EPA. Brief summaries of the studies considered by the PMRA follow.

- US EPA, Revised OP Cumulative Risk Assessment, 6/11/02. Appendix E, Water Appendix, Part 4: Effects of Drinking Water Treatment on Organophosphate Pesticides. Accessed at: http://www.epa.gov/oppsrdd1/cumulative/rra-op/III_E_WaterAppendix/III_E_4.pdf (need PMRA number)

This appendix provides a critical review of data used by US EPA to assess the effects of water treatment on transformation of organophosphorous (OP) pesticides. The review indicates that OP pesticides are transformed in chlorinated drinking water. Chemical oxidation of the organophosphorus compounds led to the formation of oxons for azinphos-methyl, chlorpyrifos, diazinon, and malathion. The oxons were more stable than their parent OP pesticides, and degradation of oxons was attributed to non-chlorine degradation processes and/or hydrolysis.

- US EPA, Revised OP Cumulative Risk Assessment, 6/11/02. Appendix E, Water Appendix, Part 3: Water Exposure Assessment, Preliminary Analysis of the USGS-EPA Pilot Reservoir Monitoring Program. Accessed at: http://www.epa.gov/oppsrdd1/cumulative/pra-op/iii_e_3-f.pdf (need PMRA number)

The US EPA conducted a pilot reservoir monitoring project that measured pesticide concentrations in raw and finished drinking water. Several organophosphorous pesticides and their transformation products were included in the study. The data indicate that the concentrations of most parent OPs were reduced to below the detection limit during water treatment, and that oxidative transformation products were detected in the finished water. Table III.E.3.9 in the US EPA assessment reports estimates of water treatment reduction factors for selected OPs, and these range from 64 to 97% for malathion. The report cautions that individual water treatment processes can vary widely, and thus it is difficult to generally assess the impact of water treatment processes on pesticide removal and transformation.

- Tierney, D.P., B.R. Christensen, and V.C. Culpepper. 2001. Chlorine Degradation of Six Organophosphorus Insecticides and Four Oxons in Drinking Water Matrix. Submitted by Syngenta Crop Protection, Inc. Greensboro, N.C. Performed by Syngenta Crop Protection, En-fate, LLC, and EASI Laboratory.

The US EPA assessment of the exposure due to malathion residues in drinking water, 2nd revision indicated that this study showed relatively complete conversion of the parent to the oxon transformation product during the chlorination phase of drinking water treatment. (need PMRA number)

- US EPA Biological and Economic Analysis Division. 2005. Results of Studies of the Chlorination of Dimethoate and Malathion and Stability Characterization of the Oxygen Analogs, Omethoate and Malaoxon in Chlorinated Water. Office of Pesticide Programs. Washington, DC. (need PMRA number)

The data from this study indicate that malaoxon forms from malathion by chlorination during drinking water treatment. There are, however, unresolved analytical chemistry issues for this study relating to malathion/malaoxon and the study authors recommend only using the results qualitatively at this time. When the analytical issues are resolved for this study the PMRA will consider more quantitative use of this data if the issues are resolved satisfactorily.

This study consisted of two experiments to investigate the conversion of malathion and dimethoate to their oxygen analogues, malaoxon and omethoate. The first experiment was conducted with laboratory water (HPLC water adjusted to pH 7) and the second experiment was conducted with raw water from two drinking water treatment sites adjusted to pH 8.5. The experiments were conducted by two independent laboratories. For both the laboratory and the raw drinking water both laboratories demonstrated a loss of malathion to below the limit of detection (250 ppt) with the simultaneous increase of its oxygen analog within the first 24 hours of chlorination. Quantitatively, there were differences in the degree of conversion between the two laboratories. The maximum conversion of malathion to malaoxon was 41% and 197% for the laboratory water and 43% and 132% for the raw drinking water at the two laboratories. In the raw drinking water samples the concentrations measured for malaoxon ranged from 4.4 – 9.9 ppb after 60 minutes to 0.58 – 3.17 ppb after 72 hours. No conversion of malathion to the oxygen analog was detected in the non-chlorinated samples. Further studies would be required to resolve the analytical inconsistencies of the results.

Table 2 Summary of the Monitoring Studies Available

Data Source	DETECTION FREQUENCY					CONCENTRATION PERCENTILES (µg/L) (Analysis includes only data with detections)			
	Location	Min detection or detection limit (µg/L)	# of systems tested (or absolute number of samples)	# of systems or samples with detections	% Detection frequency	Mean detection (µg/L)	95th	Absolute Max	Arithmetic Mean including non-detects at ½ LOD
Malathion Residues in Municipal drinking water sources									
PMRA 1307585	Treated Water Alberta (1995 – 2000)	0.05	1315	0	0	—	—	—	—
PMRA 1311143	Treated Water Alberta (1995 – 2003)	0.05	1788	0	0	—	—	—	0.025
PMRA 1311128	Manitoba Municipal Water (1981 – 1999)	0.05 – 0.9	408	0	0	—	—	—	0.29
PMRA 1307567	PEI groundwater	0.5	12 samples	0	0	—	—	—	—
PMRA 1311107	Drinking Water Reservoirs	0.015	10	0	0	—	—	—	0.03
PMRA 1345586	Manitoba Drinking water dugouts	0.9	33	0	0	—	—	—	0.45
PMRA 1307565	Wells in potatoe growing region of Quebec	0.03	43 wells	1	2.3	—	—	0.08	0.02
PMRA 1307578	Wells in Apple growing region of Quebec	0.02	42 wells/73 samples	1 sample from 1 well	2.5 (based on # of wells)	—	—	0.06	0.02
PMRA 1303805	Saskatchewan (1980 - 1992)	0.02 – 0.25	160	0	0	—	—	—	0.03
PMRA 1311119	Quebec 1999	0.03	79	1	1.3	—	—	0.04	0.01
PMRA 1311120	Groundwater 2000	0.02	79	0	0	—	—	—	0.01
PMRA 1311120	pototoc growing region 2001	0.02	79	0	0	—	—	—	0.01
PMRA 1311126	Atlantic Groundwater	0.001	184	0	0	—	—	—	0.0005
PMRA 1311112	BC Groundwater (2004)	NR	11	1	9	—	—	0.00051	—
PMRA 1345964	USA Raw water intake	0.005	323	6	1.9	—	—	0.106	—
	USA Finished tap water	0.005	228	0	0	—	—	—	—
Malathion Residues in Ambient Water that May Serve as a Drinking Water Source									
PMRA 1307585	Alberta Surface Water (1995 – 2001)	0.05	2594	7	0.27	—	—	0.041	—
PMRA 1311130	Manitoba surface water (1995 – 2001)	0.2	922	0	0	—	—	—	0.1
PMRA 1311131	Manitoba surface water 2001	0.2	102	0	0	—	—	—	0.1
	2002	0.2	101	0	0	—	—	—	0.1
	2003	0.2	64	0	0	—	—	—	0.1
PMRA 1345707	Ontario (1991 – 1993)	NR	21	5	23.8	0.04	—	0.054	—
PMRA 1357366	Ontario Tributaries – Areas of Concern (2003)	0.015	171	1	0.58	—	—	0.143	0.008
PMRA 1357367	Ontario Tributaries – Areas of Concern (2004)	0.015	234	2	0.85	0.24	0.43	0.45	0.009
PMRA 1357368	Ontario – Areas of concern and	0.015	64	1	1.5	—	—	0.026	0.008

Data Source	DETECTION FREQUENCY					CONCENTRATION PERCENTILES (µg/L) (Analysis includes only data with detections)			
	Location	Min detection or detection limit (µg/L)	# of systems tested (or absolute number of samples)	# of systems or samples with detections	% Detection frequency	Mean detection (µg/L)	95th	Absolute Max	Arithmetic Mean Including non-detects at ½ LOD
	Great Lakes connecting channels (2002)								
PMRA 1357369	Ontario - Lake Huron Tributaries (2002)	0.015	39	0	0	—	—	—	0.007
PMRA 1311112	Ontario (2003)	0.015	81	3	3.7	—	—	1.54	—
PMRA 1311116	Prairie Region Wetlands (2004)	0.015	9	0	0	—	—	—	—
PMRA 1311126	Atlantic Freshwater	0.001	29	0	0	—	—	—	0.0005
PMRA 1307581	Ruisseau Saint - Pierre	0.02	1	0	0	—	—	—	0.01
	Rivière de l'Achigan	0.02	29	0	0	—	—	—	0.01
PMRA 1307570	Rivière Saint-Régis - 1992 & 1993	0.03	30 samples	2	6.7	0.07	—	0.1	0.02
PMRA 1307569	Rivière 1994	0.01	45	3	6.7	0.02	—	0.02	0.01
	Chibouet 1995	0.01	38	1	2.6	—	—	0.35	0.02
	Rivière St. Régis 1994	0.01	47	0	0	—	—	—	0.01
	1995	0.01	34	1	2.9	—	—	0.01	0.01
	Rivière St. 1994	0.01	34	3	8.8	0.01	—	0.02	0.01
	Hurons 1995	0.01	35	1	2.9	—	—	0.07	0.01
PMRA 1307568	Rivière 1996	0.02	40	1	2.5	—	—	0.07	0.01
	Chibouet 1997	0.02	37	1	2.7	—	—	0.05	0.01
	1998	0.02	42	0	0	—	—	—	0.01
	Rivière des 1996	0.02	41	1	2.4	—	—	0.02	0.01
	Hurons 1997	0.02	39	0	0	—	—	—	0.01
	1998	0.02	45	0	0	—	—	—	0.01
	Rivière St. 1996	0.02	41	1	2.4	—	—	0.09	0.01
	Régis 1997	0.02	40	1	2.5	—	—	0.02	0.01
	1998	0.02	51	4	7.8	—	—	0.39	0.01
PMRA 1307571	Rivière 1999	0.02	45	6	13.3	0.08	0.30	0.38	0.02
	Chibouet 2000	0.02	40	1	2.5	—	—	0.06	0.011
	2001	0.02	46	0	0	—	—	—	0.01
	Rivière des 1999	0.02	45	0	0	—	—	—	0.01
	Hurons 2000	0.02	42	1	2.4	—	—	0.93	0.032
	2001	0.02	44	0	0	—	—	—	0.01
	Rivière St. 1999	0.02	45	4	8.9	0.15	0.45	0.52	0.023
	Régis 2000	0.02	43	2	4.7	0.48	—	0.93	0.032
	2001	0.02	45	3	6.7	0.08	0.13	0.14	0.015
PMRA 1398451	Chibouet 2002	0.02	43	1	2.3	—	—	0.08	0.01
PMRA 1398452	2003	0.02	41	5	12.2	0.15	0.36	0.42	0.03
PMRA 1398453	2004	0.02	41	0	0	—	—	—	0.01
	Des Hurons 2002	0.02	42	0	0	—	—	—	0.01

Data Source	DETECTION FREQUENCY					CONCENTRATION PERCENTILES (µg/L) (Analysis includes only data with detections)			
	Location	Min detection or detection limit (µg/L)	# of systems tested (or absolute number of samples)	# of systems or samples with detections	% Detection frequency	Mean detection (µg/L)	95th	Absolute Max	Arithmetic Mean Including non-detects at ½ LOD
PMRA 1307578	2003	0.02	41	0	0	—	—	—	0.01
	2004	0.02	41	1	2.4	—	—	0.03	0.01
	St-Regis 2002	0.02	40	11	27.5	0.22	0.89	1.5	0.07
	2003	0.02	39	2	5.1	0.08	0.13	0.14	0.01
	2004	0.02	39	0	0	—	—	—	0.01
	Sr-Zephirin 2002	0.02	42	0	0	—	—	—	0.01
	2003	0.02	39	0	0	—	—	—	0.01
	2004	0.02	39	0	0	—	—	—	0.01
	Surface water samples in apple growing region of Quebec (1994 – 1996)	0.015 – 0.03	111	0	0	—	—	—	0.008
	PMRA 1311104 British Columbia	0.0003 – 0.002	12	1	8.3	—	—	0.00052	0.0004
	PMRA 1307576 Great Lakes	0.0003	24	2	8.3	—	—	0.02	—
	PMRA 1307591 Lake Ontario Tributaries - 2000	0.01	75	0	0	—	—	—	0.005
	PMRA 1401897 Lake Ontario Tributaries - 2001	0.01	119	0	0	—	—	—	0.005
	PMRA 1401896 BC Region 2003 - 2005	NR	NR	NR	22	—	—	0.0751	—
	PMRA 1403269 Ontario 2003	NR	164	1	0.64	—	—	0.143	—
	Ontario 2004	NR	229	2	0.88	—	—	0.449	—
PMRA 1307555	US Urban Streams	0.01	215	—	14	—	—	0.41	—
PMRA 1644008	USA	0.002 - 0.01	10422	29	0.28	0.01	0.04	0.1	0.007
PMRA 1644011	USA	0.005 - 0.15	22772	1616	7.1	0.05	0.16	9.6	0.009
PMRA 1644022	USA	—	—	—	—	—	—	—	—
Malathion Residues that are Unlikely to be Used as a Drinking Water Sources									
PMRA 1311140	Lethbridge Alberta Storm Drains	0.05	39	4	10	0.07	0.19	0.22	0.03
PMRA 1311123	Effluent from Laval municipal	0.02	26	2	7.7	0.48	0.78	0.81	0.129
	wastewater Repentigny	0.02	28	2	7.1	1.2	2.01	2.1	0.179
	treatment CUQ (est)	0.02	28	1	3.6	—	—	0.15	0.102
	plants - CUQ (ouest) Quebec	0.02	29	2	6.9	0.13	0.17	0.17	0.102

Table 3 Summary of the Monitoring Studies Available Malaoxon

Data Source	DETECTION FREQUENCY				CONCENTRATION PERCENTILES (µg/L)				
	Location	Min detection or detection limit (µg/L)	# of systems tested (or absolute number of samples)	# of systems or samples with detections	% Detection frequency	Mean detection (µg/L)	95th	Absolute Max	Arithmetic Mean Including non-detects at ½ LOD
PMRA 1644011	USA	0.005 - 0.15	3631	6	0.17	0.05	0.14	0.18	0.026
PMRA 1644008	USA	0.002 - 0.01	2666	1	0.04	—	—	0.015	0.028
PMRA 1345964	USA Raw water intake	0.016	317	0	0	—	—	—	—
	USA Finished water intake	0.016	221	11	5	—	—	0.556	—

**Appendix XXI Malathion uses for which information on value is sought:
site-pest combinations of Commercial and or/Restricted
Class products that are not supported by the technical
registrant as well as not supported**

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
USC 2 -Aquatic non-food sites				
Mosquito breeding areas	Mosquitoes (larvae)	N	N/A	See Section 2.3
Standing water (self-contained)	Mosquitoes (larvae)			
USC 5 -Greenhouse food crops				
Mushroom houses	mites	P (Application method applied as a paint not supported)	Yes	See Section 7.0
	phorid flies, sciarid flies	P, M (Application method applied as a paint not supported EC formulation supported. WP and DU formulations not supported)		
USC 6 -Greenhouse ornamental crops				
Carnation, chrysanthemum, geranium, rose, snap dragon	aphids, mealybugs, spider mites, thrips, whiteflies	P (Fogging not supported)	N/A	See Section 2.3
	greenhouse whitefly			
Ornamental plants	aphids, mealybugs, spider mites, thrips	P (EC formulation supported. WP formulation not supported)	N/A	See Section 2.3
	greenhouse whitefly			

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
USC 8 - Livestock for Food				
Beef and dairy cattle (non-lactating)	black flies,	Y	Y	See Section 7.0
	face fly			
	stable fly			
	flies			
	gnats			
	horn fly			
	lice			
Dairy cattle (lactating)	mosquitoes	Y	Y	See Section 7.0
	flies			
	horn fly			
	lice			
Goats	black flies,	Y	Y	See Section 7.0
	face fly,			
	stable fly			
Goats (non-milking)	mosquitoes	Y	Y	See Section 7.0
	flies			
	horn fly			
Poultry	lice	Y	Y	See Section 7.0
	Northern fowl mite,			
	red mite (aid to control)			
Sheep	horn fly,	Y	Y	See Section 7.0
	lice			
	mosquitoes,			
	ked			
Swine	ticks	Y	Y	See Section 7.0
	horn fly			
	lice			
	sarcoptic mange mite			
	ticks			

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
USC 10-Seed treatments food and feed and Seed Treatment Non-Food USC 11				
Seeds (field and garden)	confused flour beetle, flat grain beetle, granary weevil, Indianmeal moth, lesser grain borer, rusty grain beetle, saw toothed grain beetle	N	N/A	See Section 2.3
USC 12 -Stored food and feed				
Grains	flour beetles, granary weevil, rice weevil	Y	Y	See Section 7.0
Barley	grain mites	Y	Y	See Section 7.0
	red flour beetle			
	lesser grain borer, rusty grain beetle			
	Indianmeal moth			
	merchant grain beetle			
	rice weevil			
	confused flour beetle, flat grain beetle granary weevil, sawtoothed grain beetle			
Corn	grain mites	Y	Y	See Section 7.0
	lesser grain borer, red flour beetle, rusty grain beetle			
	Indianmeal moth			
	confused flour beetle, flat grain beetle, granary weevil, rice weevil, sawtoothed grain beetle			

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
Oats	grain mites	Y	Y	See Section 7.0
	red flour beetle			
	lesser grain borer,			
	rusty grain beetle			
	Indianmeal moth			
	merchant grain beetle			
	rice weevil			
	confused flour beetle, flat grain beetle, granary weevil, sawtoothed grain beetle			
Rice	confused flour beetle, flat grain beetle, granary weevil, Indianmeal moth, lesser grain borer, rusty grain beetle, sawtoothed grain beetle	Y	Y	See Section 7.0
	merchant grain beetle			

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
Rye	grain mites	Y	Y	See Section 7.0
	red flour beetle			
	lesser grain borer,			
	rusty grain beetle			
	Indianmeal moth			
	merchant grain beetle			
	rice weevil			
	confused flour beetle, flat grain beetle, granary weevil, sawtoothed grain beetle			
Wheat	rain mites	Y	Y	See Section 7.0
	red flour beetle			
	lesser grain borer,			
	rusty grain beetle			
	Indianmeal moth			
	merchant grain beetle			
	rice weevil			
	confused flour beetle, flat grain beetle granary weevil, sawtoothed grain beetle			

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
USC 13 -Terrestrial feed crops				
Alfalfa	alfalfa blotch	P (Ground ULV not supported)	N/A	See Section 2.3
	leafminer			
	spider mites			
	spittlebugs (adults)			
	alfalfa weevil,			
	aphids,			
	grasshoppers,			
	leafhoppers,			
	Lygus bug,			
	spittle bugs			
	potato leafhopper			
	young grasshoppers			
	alfalfa weevil (larvac)			
Feedlot and stabling areas and pastures	adult mosquitoes, house flies, stable fly	N	N/A	See Section 2.3
USC 20 -Structural				
Bakeries, Canneries, Meat processing plants	flies,	N	N/A	See Section 2.3
	hornets,			
	mosquitoes,			
	wasps			
	flour beetles			
	granary weevil			
	rice weevil			
Barns, Pig pens, Outbuildings	chicken red mite,	N	N/A	See Section 2.3
	flies,			
	northern fowl mite,			
	poultry lice			
	ticks			

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
Dairies	ants	N	N/A	See Section 2.3
	cockroaches, crickets, earwigs, flies, grain insects, lice, mites, mosquitoes, silverfish, springtail, weevils			
	spiders			
	clover mite, grasshoppers, millipedes, spiders, sowbugs			
Dairy barn	flies, hornets, mosquitoes, wasps	N	N/A	See Section 2.3
	ants, cockroaches, silverfish, spiders			
Dwellings foundations	ants, cockroaches, silverfish, spiders	P (Use in indoor dwellings not supported by registrant. Outdoor foundation and spot perimeter treatment spraying are supported by registrant)	NA	See Section 2.3
Farm buildings (indoor)	house fly, mosquitoes, stable fly	N	N/A	
	lice			
Food processing plants	ants, spiders	N	N/A	See Section 2.3
	cockroaches, silverfish, spiders			

Site(s)	Pest (s)	Supported use by registrant? ¹	Concerns from Risk Assessments? ²	Note to Risk Assessment
	crickets, earwigs, flies, grain insects, lice, mites, mosquitoes, silverfish, spiders, springtail, weevils hornets wasps grasshoppers, millipedes, sowbugs clover mite (exterior wall surface) booklouse, carpet beetles, clothes moth			
Poultry houses and shipping crate	chicken red mite, flies, poultry lice, northern fowl mite chicken mite lice ticks	N	N/A	See Section 2.3
USC 25 Human Habitat and Recreational Areas				
Farm yards, Pens, Feedlots, Pastures, Stabling areas, Manure piles, Garbage areas, Around buildings and undergrowth	house fly, mosquitoes, stable fly small flying insects	N	N/A	See Section 2.3
Municipal dumps, Refuse areas, Sewage lines	cockroaches	N	N/A	See Section 2.3

USC = Use Site Category.

¹ Y = use is supported by the registrant; N = use is not supported by the registrant; P = the registrant partially supports the use pattern.

² Y = there are risk concerns for this use; N = there are no risk concerns for this use; and P = partial risk concern for the use (for example, PMRA has risk concerns only for some application methods of the use).

Appendix XXII Proposed Label Amendments for Products Containing Malathion

NOTE: The following information is divided according to product type. Please read each section carefully and make appropriate changes to your product labels.

The label amendments presented below do not include all label requirements for individual end-use products, such as first aid statements, disposal statements, precautionary statements and supplementary protective equipment. Additional information on labels of currently registered products should not be removed unless it contradicts the label statements given below.

A. Technical Class Products Containing Malathion

The following warning statement should appear on the **Primary** panel of the technical product labels:

Caution: Eye Irritant.

B. Commercial Class Products Containing Malathion

TOXICOLOGICAL INFORMATION

Malathion is an organophosphate that is a cholinesterase inhibitor. Typical symptoms of overexposure to cholinesterase inhibitors include headache, nausea, dizziness, sweating, salivation, runny nose and eyes. This may progress to muscle twitching, weakness, tremor, incoordination, vomiting, abdominal cramps and diarrhea in more serious poisonings. A life-threatening poisoning is signified by loss of consciousness, incontinence, convulsions and respiratory depression with a secondary cardiovascular component. Treat symptomatically. If exposed, plasma and red blood cell cholinesterase tests may indicate degree of exposure (baseline data are useful). Atropine, only by injection, is the preferable antidote. Oximes, such as pralidoxime chloride, may be therapeutic if used early; however, use only in conjunction with atropine. In cases of severe acute poisoning, use antidotes immediately after establishing an open airway and respiration. With oral exposure, the decision of whether to induce vomiting or not should be made by an attending physician.

STORAGE

Do not contaminate water, food, or feed by storage or disposal.

Keep in original container during storage. Isomalathion, a toxic metabolite of malathion forms when malathion product is stored at elevated temperatures or for extended periods of time. Malathion product must be stored in a cool (<20-23°C), dry, well ventilated place away from seed, fertilizer or other pesticides and for no longer than one year.

WETTABLE POWDER IN WATER SOLUBLE PACKAGING (WSP):

The following label instructions should be added to clearly indicate directions for water soluble packaging:

PRIMARY PANEL:

NET CONTENTS (Example): 1.5 kg (20 x 75 g water soluble bag)

DIRECTIONS FOR USE:

Product X MAL is a dry powder sealed within a water soluble bag. Drop intact water soluble bag directly into spray tank. The water soluble bag and pesticide will dissolve readily in water. Do not allow the water soluble bag to become wet prior to use. Do not handle individual water soluble bag with wet hands or wet gloves as this may cause breakage. Do not open or puncture water soluble bag for any reason. Do not use opened or punctured water soluble bag for any reason. If broken water soluble bags are found when container is opened, avoid contact with, and inhalation of the product. Wear chemical resistant coveralls, chemical resistant gloves and a respirator to dispose of broken water soluble bags according to DISPOSAL section.

STORAGE:

Do not remove water soluble bag from container except for immediate use. Keep container closed when not in use.

USE PRECAUTIONS:

There may be potential for exposure to bystanders from drift following pesticide application to agricultural areas. In the interest of promoting best management practices and to minimize human exposure from spray drift or from spray residues resulting from drift, the following label statement is required:

Apply only when the potential for drift to areas of human habitation or areas of human activity such as houses, cottages, schools and recreational areas is minimal. Take into consideration wind speed, wind direction, temperature inversions, application equipment and sprayer settings.

PERSONAL PROTECTIVE EQUIPMENT:

For all product labels, the following statement is required to mitigate the risk of exposure to malathion:

Wear long pants, long sleeved shirts, and chemical-resistant gloves during mixing/loading, application, clean-up and repair. Chemical-resistant gloves are not required while operating groundboom sprayers.

For product labels containing uses on Dairy and Beef Cattle, Goats, and Sheep, the following statement is required:

Handwand Equipment:

Limit the amount of active ingredient handled per day to 8 kg per person (approx. 820 L at a rate of 10 g ai/L).

For product labels with Stored Grain uses (wheat, oats, corn, rice, rye, and barley), the following statements are required:

Dusts: Limit the amount of active ingredient handled per day to 100 kg per person (approx. 6650 metric tons at a rate of 15 g ai/ton).

Liquids (Emulsifiable Concentrates): Limit the amount of active ingredient handled per day to 865 kg per person (approx. 28,800 metric tons at a rate of 30 g ai/ton)

For all ULV products used for agricultural crops (food and feed crops), the following is required:

For ULV Ground Applications:

Limit the amount of active ingredient handled per day to 95 kg per person (approx. 70 ha at a rate of 1375 g ai/ha, and 150 ha at a rate of 653 g ai/ha).

Wear cotton coveralls over long pants, long sleeved shirts, and chemical-resistant gloves during mixing/loading, application, clean-up and repair.

For ULV Aerial Applications:

Limit the amount of active ingredient handled per day to 1125 kg per person (approx. 820 ha at a rate of 1375 g ai/ha, and 1700 ha at a rate of 653 g ai/ha).

Wear cotton coveralls over long pants, long sleeved shirts, and chemical-resistant gloves during mixing/loading, clean-up and repair.

For product labels containing uses for flour mills, flour mill warehouses, feed mills, and dwelling foundations, the following statements are required:

Handwand Equipment:

Limit the amount of active ingredient handled per day to 6 kg per person (approx. 190 L at a rate of 32.5 g ai/L).

Wear chemical-resistant coveralls over long pants, long sleeved shirts, chemical-resistant gloves, and chemical-resistant footwear during mixing/loading, application, clean-up and repair.

For product labels containing uses in and around buildings that house domestic animals, around yards, homes, processing plants, and other buildings: walls, ceilings, stanchions, windows, fences, and garbage cans, the following statements are required:

Handwand Equipment:

Limit the amount of active ingredient handled per day to 12 kg per person (approx. 1135 L at a rate of 10.5 g ai/L).

Wear cotton coveralls over long pants, long sleeved shirts, and chemical-resistant gloves during mixing/loading, application, clean-up and repair.

For all commercial class labels, the following statement must be added:

Outdoor use only in residential areas. Residential areas are defined as any use site where bystanders including children could be exposed during or after application. This includes homes, schools, public buildings or any other areas where the general public including children could be exposed.

For product labels containing uses for Garden areas, outside foundations and yards, the following is required:

Treatment of outdoor structural foundations only, and the 1 m wide path surrounding the foundation.

References to gardens and yards must be removed from all labels.

DIRECTION FOR USE

Since the technical registrant does not support the following uses, they must be removed from all current commercial end-use product labels:

- Aquatic non-food sites: mosquito breeding areas and standing water;
- Greenhouse food crops: mushroom beds and houses (wetable powder and dust formulations and application method of painting on wooden surfaces);
- Greenhouse non-food crops: carnation, chrysanthemum, geranium, rose, snap dragon and ornamental plants (wetable powder formulation and the application method of fogging);
- Seed treatments food and feed and seed treatment non-food: seeds (field and garden);

- Terrestrial feed crops: alfalfa (ground ULV);
- Structural: bakeries, canneries, meat processing plants, barns, pig pens, outbuildings, dairies, dairy barns, dwelling foundations (indoor), farm buildings (indoor), food processing plants, poultry houses and shipping crates;
- Human habitat and recreational areas: farm yards, pens, feedlots, pastures, stabling areas, manure piles, garbage areas and around buildings and undergrowth to control house fly, mosquitoes, stable fly, and small flying insects as a space spray, mist, fog, aerosol and ground ULV;
- municipal dumps, refuse areas, sewage lines; and
- Residential outdoors: yards.

Number of Applications:

Based on information available for the post-application assessment, all labels must be changed to limit the maximum number of applications and provide minimum number of days between applications.

Maximum Number of Applications per Year and Minimum Application Intervals

Crop		
	Maximum Number of Applications per Year	Minimum Interval (days)
cereal crops (barley, oats, wheat, grasses or legumes grown for hay), pasture and range, potato, beets (table), turnips, carrots, horseradish, parsnip, sugar beets, turnip, salsify, radish, rutabaga, onions, garlic, leek, shallot, lettuce, spinach, celery, collard, kale, parsley, swiss chard, endive, kohlrabi, watercress, dandelion, broccoli, brussel sprouts, cabbage, cauliflower, cucumber, melon, pumpkin, squash, peach, plum, prune plum, cherry, barley, canola, oats, wheat, rye, wild rice (cultivated), rapeseed, rape, mustard, flax, asparagus, grapes, tobacco, cranberries	1	N/A
greenhouse lettuce, raspberry, currant, gooseberry	2	10
greenhouse ornamentals, outdoor ornamentals	4	10
beans, lentils, peas, blackberry, boysenberry, dewberry, strawberry, loganberry	2	7
eggplant, pepper, tomato	4	7
apples, apricots, pears	2	10

Crop		
	Maximum Number of Applications per Year	Minimum Interval (days)
blueberry	3	4
corn (grain, forage)	4	3
alfalfa (2 applications per cut to max 4 per year), clover, sweet clover, canary grass (for seed)	2	14

Restricted Entry Intervals:

The restricted entry intervals listed below must be added to the appropriate labels.

Recommended Restricted Entry Intervals

Activity	Proposed REI (days)
Greenhouse lettuce, cereal crops (barley, oats, wheat, grasses or legumes grown for hay), pasture and range, potato, sugar beets, turnip, salsify, radish, rutabaga, onions, garlic, leek, shallot, eggplant, pepper, tomato, blackberry, boysenberry, dewberry, strawberry, loganberry, currant, gooseberry, barley, canola, oats, wheat, rye, wild rice (cultivated), corn (grain, forage), alfalfa, clover, sweet clover, canary grass (for seed), rapeseed, rape, mustard, flax, asparagus, tobacco, cranberries	
All activities	12 hrs
Beets, turnips, carrots, horseradish, parsnip, lettuce, spinach, celery, collard, kale, parsley, swiss chard, endive, kohlrabi, watercress, dandelion, beans, lentils, peas, cucumber, melon, pumpkin, squash, raspberry	
All activities	1
Greenhouse ornamentals, broccoli, brussel sprouts, cabbage, cauliflower, blueberries	
All activities	2
Outdoor ornamentals	
All activities	3
Apples, apricots, pears	
Thinning	3

Activity	Proposed REI (days)
Hand harvest, irrigation	2
All other activities	12 hrs
Peach, plum, prune plum, cherry	
Thinning	3
All other activities	1
Grapes	
Girdling, cane turning	5
Hand harvest, training, tying, leaf pulling, hand pruning, thinning	4
All other activities	12 hrs

For all non-ULV labels:

ENVIRONMENTAL HAZARDS:

TOXIC to aquatic organisms. Observe buffer zones specified under DIRECTIONS FOR USE.

TOXIC to birds.

TOXIC to bees exposed to direct treatment, drift, or residues on flowering crops or weeds. **DO NOT** apply this product to flowering crops or weeds if bees are visiting the treatment area. Minimize spray drift to reduce harmful effects on bees in habitats close to the application site.

TOXIC to certain beneficial insects. Minimize spray drift to reduce harmful effects on beneficial insects in habitats next to the application site such as hedgerows and woodland.

To reduce runoff from treated areas into aquatic habitats avoid application to areas with a moderate to steep slope, compacted soil, or clay.

Avoid application of this product when heavy rain is forecast.

Contamination of aquatic areas as a result of runoff may be reduced by including a vegetative strip between the treated area and the edge of the water body.

The use of this chemical may result in contamination of groundwater particularly in areas where soils are permeable (for example, sandy soil) and/or the depth to the water table is shallow.

DIRECTIONS FOR USE:

As this product is not registered for the control of pests in aquatic systems, **DO NOT** use to control aquatic pests.

DO NOT contaminate irrigation or drinking water supplies or aquatic habitats by cleaning of equipment or disposal of wastes.

Field sprayer application: **DO NOT** apply during periods of dead calm. Avoid application of this product when winds are gusty. **DO NOT** apply with spray droplets smaller than the American Society of Agricultural Engineers (ASAE) coarse classification. Boom height must be 60 cm or less above the crop or ground.

Airblast application: **DO NOT** apply during periods of dead calm. Avoid application of this product when winds are gusty. **DO NOT** direct spray above plants to be treated. Turn off outward pointing nozzles at row ends and outer rows. **DO NOT** apply when wind speed is greater than 16 km/h at the application site as measured outside of the treatment area on the upwind side.

Aerial application: **DO NOT** apply during periods of dead calm. Avoid application of this product when winds are gusty. **DO NOT** apply when wind speed is greater than 10 km/h at flying height at the site of application. **DO NOT** apply with spray droplets smaller than the American Society of Agricultural Engineers (ASAE) coarse classification. To reduce drift caused by turbulent wingtip vortices, the nozzle distribution along the spray boom length **MUST NOT** exceed 65% of the wing- or rotorspan.

Buffer zones:

Use of the following spray methods or equipment **DO NOT** require a buffer zone: hand-held or backpack sprayer and spot treatment.

The buffer zones specified in the table below are required between the point of direct application and the closest downwind edge of sensitive freshwater habitats

(such as lakes, rivers, sloughs, ponds, prairie potholes, creeks, marshes, streams, reservoirs and wetlands) and estuarine/marine habitats.

Method of application	Crop		Freshwater Habitat of Depths:		Estuarine/Marine Habitats of Depths:	
			Less than 1 m	Greater than 1 m	Less than 1 m	Greater than 1 m
Field sprayer*	Sugar beet		15	5	1	1
	Canary grass (for seed), cereal crops (barley, oats, wheat) and grasses or legumes grown for hay, currant, gooseberry, mustard		20	10	2	1
	Mustard (condiment type only), flax, canola, tobacco, wild rice		25	10	2	1
	Clover, cauliflower, collards, cranberry, dandelion, endives, garlic, horseradish, kohlrabi, leek, melon, parsley, salsify, shallot, swiss chard, watercress, sweet clover, tomato, onion, pea, potato, pumpkin, lentil		30	15	3	1
	Pasture and range (grass), cucumber, eggplant, kale, lettuce, asparagus, bean, beet, broccoli, Brussels sprout, cabbage, carrot, radish, squash, turnip, barley, rye, wheat, pepper, rutabaga		35	15	3	1
	Celery, spinach, grape		40	20	4	2
	Alfalfa		45	20	4	2
	Blueberry		50	20	4	2
	Blackberry, boysenberry, dewberry, loganberry, strawberries		65	30	5	3
	Raspberry, corn		75	35	5	3
Airblast	Currant, gooseberry	Early growth stage	60	55	35	25
		Late growth stage	50	45	25	15
	Blueberry, grape	Early growth stage	70	65	45	35

Method of application	Crop		Freshwater Habitat of Depths:		Estuarine/Marine Habitats of Depths:	
			Less than 1 m	Greater than 1 m	Less than 1 m	Greater than 1 m
		Late growth stage	60	50	35	25
	Blackberry, boysenberry, dewberry, loganberry, cherry, peach, plum, prune plum, pear, raspberry	Early growth stage	75	70	50	40
		Late growth stage	65	60	40	30
	Apples, apricots, crabapples	Early growth stage	80	70	50	45
		Late growth stage	70	60	40	35
Aerial	alfalfa	Fixed wing	625	425	125	40
		Rotary wing	450	250	60	25
	canary grass (for seed)	Fixed wing	525	325	30	10
		Rotary wing	325	150	20	10
	Cereal crops (barley, oats, wheat) and grasses or legumes grown for hay	Fixed wing	550	325	40	15
		Rotary wing	325	175	25	10
	mustard, flax, canola,	Fixed wing	550	325	40	15
		Rotary wing	325	175	25	10
	lentil	Fixed wing	725	400	70	20
		Rotary wing	450	250	40	15
	wild rice (cultivated)	Fixed wing	325	225	55	15
		Rotary wing	225	125	30	10

Method of application	Crop		Freshwater Habitat of Depths:		Estuarine/Marine Habitats of Depths:	
			Less than 1 m	Greater than 1 m	Less than 1 m	Greater than 1 m
	sweet clover	Fixed wing	575	350	65	20
		Rotary wing	375	200	40	15
	barley, oats, rye, wheat	Fixed wing	550	350	80	25
		Rotary wing	375	200	45	15

*For field sprayer application, buffer zones can be reduced with the use of drift reducing spray shields. When using a spray boom fitted with a full shield (shroud, curtain) that extends to the crop canopy, the labelled buffer zone can be reduced by 70%. When using a spray boom where individual nozzles are fitted with cone-shaped shields that are no more than 30 cm above the crop canopy, the labelled buffer zone can be reduced by 30%.

For tank mixes, consult the labels of the tank-mix partners and observe the largest (most restrictive) buffer zone of the products involved in the tank mixture and apply using the coarsest spray (ASAE) category indicated on the labels for those tank mix partners.

For product labels with greenhouse and mushroom house uses:

DIRECTIONS FOR USE:

DO NOT allow effluent or runoff from greenhouses or mushroom houses containing this product to enter lakes, streams, ponds or other waters.

For all ULV labels:

ENVIRONMENTAL HAZARDS:

TOXIC to bees exposed to direct treatment, drift, or residues on flowering crops or weeds.

DO NOT apply this product to flowering crops or weeds if bees are visiting the treatment area. Minimize spray drift to reduce harmful effects on bees in habitats close to the application site.

TOXIC to certain beneficial insects. Minimize spray drift to reduce harmful effects on beneficial insects in habitats next to the application site such as hedgerows and woodland.

DIRECTIONS FOR USE:

DO NOT contaminate irrigation or drinking water supplies or aquatic habitats by cleaning of equipment or disposal of wastes.

Field sprayer application: **DO NOT** apply during periods of dead calm. Avoid application of this product when winds are gusty.

Aerial application: **DO NOT** apply when wind speed is greater than 16 km/h at flying height at the site of application.

C. Domestic Class Products Containing Malathion**TOXICOLOGICAL INFORMATION**

This product contains a pesticide that is a cholinesterase inhibitor (anti-cholinesterase compound). Symptoms of human poisoning may include headache, weakness, sweating, blurred vision, nausea and diarrhea. Obtain medical attention or call a poison centre at once. Atropine is antidotal."

STORAGE

Do not contaminate water, food, or feed by storage or disposal. Keep in original container during storage. Isomalathion, a toxic metabolite of malathion forms when malathion product is stored at elevated temperatures or for extended periods of time. Malathion product must be stored in a cool (<20-23°C), dry, well ventilated place away from seed, fertilizer or other pesticides and for no longer than one year.

DIRECTION FOR USE:

References to garden areas on domestic labels were assumed to imply treatment to garden vegetables and fruits, and outdoor ornamentals. Any reference to garden areas must be removed from the label.

"Garden Area, Outdoor, Foundations" must be changed to:
Treatment of outdoor structural foundations only, and the 1 m wide path surrounding the foundation.

The registrant has indicated that indoor residential uses are not supported. The following statement must be added to all labels:

For outdoor use only.

PRECAUTIONS:

For best management practices, the following statement is required:

Wear rubber gloves when handling this product. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash before use.

ENVIRONMENTAL HAZARDS:

TOXIC to birds and aquatic organisms.

DIRECTIONS FOR USE:

Avoid application of this product when winds are gusty.

DO NOT apply to any body of water.

DO NOT contaminate irrigation or drinking water supplies or aquatic habitats by cleaning of equipment or disposal of wastes.

D. General Label Improvements

The current labels contain "repeat as necessary" statements for many uses. This statement should be removed and replaced by specific information indicated in the table of this appendix, titled as **Maximum Number of Applications per Year and Minimum Application Intervals**.

DIRECTIONS FOR USE:

For the product label "Registration No. 5821", the headings for sections 5 and section 6 need to be changed from "Crop(s)" to "Site(s)" and from "Rate per hectare" to "Rate".

For the product label "Registration No. 8826", for stored grain "ML / tonne of liquid grain protectant" must be changed to "ml of liquid grain protectant / 1000 kg of seed". Also, specific instructions must be changed from "in 10-20 litres of water per 1000 bushels" to "In 10-20 litres of water per 1000 kg of seed, apply as the grain is being loaded or turned into final storage.

For the product label "Registration No. 12073", the pest name "flat grain borer" must be changed to "flat grain beetle".

For the product label "Registration No. 13883", for use in empty granary bins, the application instruction, "apply 2 to 4 weeks before storing grain may be used within 1 day of storing grain" must be changed to "apply within 2 to 4 weeks before storing grain and may be used within 1 day of storing grain."

Appendix XXIII Comments to PACR2003-10 and the PMRA's Response

Comments Pertaining to the Human Health

1.0 Comments Pertaining to Toxicology Assessment

The registrant had two major areas of disagreement with the PMRA toxicology assessment published in January 8, 2003 (PACR 2003-10).

These are:

- I) The selection of the toxicology endpoints for risk assessment for children and the potential sensitivity of the young; and
- II) The selection of the toxicology endpoints for risk assessment for adults.

Response

Where possible, comments have been addressed as overall concerns or concepts. In some cases, comments raised by the registrant may no longer be applicable due to revisions to the review resulting from the review of new data, the use of benchmark dose modelling and the revised PMRA policy on the use of uncertainty factors.

The use of benchmark dose analysis

Since the initial toxicological assessment in PACR2003-10, the PMRA has sought to refine its human health risk assessment for malathion through the use of benchmark dose (BMD) modelling, in particular for the endpoint of cholinesterase inhibition. The use of a BMD is more statistically powerful than the use of a NOAEL when statistical models are able to be fitted properly to the data set. This allows the calculation of a dose at which a predetermined response is elicited, as opposed to the classic NOAEL approach in which the potential effect levels are predetermined by dose selection.

The BMD calculation is used in two manners in the current risk assessment. First, the 95% lower bounds of the BMD are used to determine a suitable point of departure for establishing reference doses and for comparing these effect levels to other observed effects in the database. A lower confidence limit is used to ensure (with 95% confidence) that the benchmark response is not exceeded. Second, by comparing the benchmark doses for critical endpoints, relative potencies are able to be calculated. In the assessment of malathion, the most common endpoint for which BMD modelling is used is that of erythrocyte (EChE) cholinesterase inhibition. BMD dose modelling of EChE inhibition is used both in the comparison of susceptibility between different age groups to the effects of malathion, as well as in determining the relative potency or toxicity adjustment factor (TAF) of malaoxon in relation to malathion.

In previous assessments investigating the effects of cholinesterase inhibiting pesticides such as the organophosphates, the PMRA's approach specifies an approximate cut-off of 20% EChE inhibition for adversity, subject to a variety of additional factors such as statistical significance, nature of the dose-response and study design. In light of this, the PMRA continues to use a benchmark dose established at 20% for EChE inhibition for its points of departure and TAF calculations.

This newly adopted approach alters the previous risk assessment and negates the need to address several queries raised by the registrant that focus on previously established points of departure. Additional points will be addressed as required.

1.1 Comments on Endpoints related to the Risk Assessment of Children and the Potential Sensitivity of the Young

- 1.1 a The registrant maintained that there were no treatment-related neurobehavioural effects in the developmental neurotoxicity assay.

Response

i) Motor Activity

Reduced motor activity was observed in female rats on PND 17 (mid and high doses), as well as PND 22 (>5 mg/kg bw/day) as evidenced by reductions in both rearing (high beam breaks) and ambulatory activity (low beam breaks). Reductions in both low and high beam breaks were observed at the lowest dose tested in females on PND22, however, control values were elevated relative to controls in an additional study used as a relevant historical control and statistical significance was not achieved. The reductions in ambulatory activity were statistically significant at 50 mg/kg bw/day and greater. A NOAEL for decreased motor activity is set at 5 mg/kg bw/day.

ii) Auditory Startle

An increase in peak amplitude was observed in all treatment groups for both auditory startle tests on PND23/24 (with and without pre-pulse signalling), albeit with a poor dose relationship. While statistical inferences remain limited due to small dose group sizes, statistically significant increases ($p \leq 0.05$) in amplitude were observed at PND 23/24 during trial block 4 in the mid dose females, as well as in block 5 in all treated females. The only change resulting from a reanalysis of the statistical significance of the data by the registrant was the presence of a significant increase in amplitude observed during block 1 of the low dose male animals. There was no consistent treatment related effect on PND60/61.

The possibility of a plateau effect has been considered, especially in light of the consistency of response between sexes on PND 23/24. Potential explanations of an increase in auditory startle include the decreased ability to learn or increased muscle tone or mental excitability. There is low concern for effects on the animal's ability to learn as the Morris maze returned negative results. Concern for increased muscle tone is attenuated by a lack of correlative findings in the functional observation battery. Some concern for mental excitability is alleviated due to the lack of aggressive response during handling.

Applicable historical data was limited to one additional study which suggested that control values were accurate. However, relevant positive control data was unavailable raising concern over the validity of the assay. Latency data used to separate peak effects due to animal reaction and background "noise" of animal movement was also not measured.

On PND 60/61, a slight decrease in habituation of startle response was observed at 5 mg/kg bw/day in females and continued to decrease in a dose-related manner. A slight decrease in habituation was observed in high dose males at the same time. There was no effect on habituation on PND 22/23.

Table 1 % Reduction in Auditory Startle Response from Block 1 to 5

Postnatal Day	%Reduction in Response / Habituation ((Block 5 - Block 1)/Block 1) in Female Rats			
	0 mg/kg bw/day	5 mg/kg bw/day	50 mg/kg bw/day	150 mg/kg bw/day
23/24	37.3%	28.5%	12.6%	28.8%
60/61	35.1%	22.3%	15.4%	12.7%

Overall, there is moderate concern with the validity of the auditory startle test and low concern for effects identified in the auditory startle assay, especially with the points of departure to be used in the current risk assessment.

iii) Flattened Gait

Flattened gait was observed in 1 low- 3 mid- and 6 high- dose males on PND60, but in only one high dose female animal. Flattened gait had been observed on PND21 and PND35, but was typically only observed in one out of ten animals of either sex, with the exception of 3 high dose females on PND 21.

The PMRA concludes that neurobehavioural effects were present in the developmental assay, but has modified the NOAEL to 5 mg/kg bw/day.

- 1.1b The registrant suggested that PND 4-11 pups are developmentally equivalent to human fetuses and hence, data pertaining to these pups are not relevant to children.

Response

The PMRA maintains that the sensitivity of pups exposed during PND 4-11 justify concern for human children. Evidence driving this concern includes the following:

- i) Lower effects levels for cholinesterase inhibition have been observed in PND11 pups following acute exposure when compared to adult animals in the same study. No other age of pups have been examined under an acute dosing scenario.
- ii) Lower effect levels for cholinesterase inhibition have been observed in PND21 pups following repeat dose exposure when compared to both adult and pregnant animals in the same study.

iii) While there remains considerable uncertainty in the continuous evolution of developmental biology, the equivalency of neurological development of rat pups on any given date (eg. PND11) and human children at birth is unlikely. Since neurological development of humans continues during the period leading up to puberty, many of the key neurological processes that occur pre and post-weaning in the rat may correlate with human processes which occur postnatally including neurogenesis, gliogenesis and synaptogenesis. In addition, specific brain regions are known to mature postnatally in both rats and humans including the hippocampus and the cerebellum.

iv) Evidence is continuously being developed suggesting a role of AChE in neurological morphogenesis.

v) Furthermore, the registrant indicates that rats on PND4 are not sensitive to the effects of malathion from the dam's milk. While this may hold true for rat breast milk, the extent of exposure from milk was not quantified in the comparative cholinesterase study accompanying the DNT study. Therefore, there remains uncertainty as to the extent of exposure when newborn children are exposed from other routes of exposure such as more solid food.

1.2 Comments on endpoints related to the Risk Assessment of Adults

1.2a The registrant disagreed with the toxicology values (NOAEL/LOAEL) selected for the risk assessments relevant to adults i.e the short- and intermediate-term dermal assessment and the short-term aggregate assessment for adults.

Response

PMRA is aware that the recently submitted short-term dermal assay in rabbits was conducted in order to provide a more accurate effect level for cholinesterase inhibition, as observed in a previous study conducted by the registrant in 1998. Due to the increased robustness (including increased test group sizes, increased number of dose groups, increased purity of technical, etc.) and more conservative findings in the new short-term dermal assay, the PMRA is basing its current assessment on the most recent study.

The use of the 21-day dermal rabbit assay for cholinesterase determination included the sampling of blood occurring approximately 24 hours after initial dermal application, or 18 hours following the washing of the skin for the removal of the test agent. However, this raises some concerns as no data indicating the time to peak cholinesterase inhibition following repeat dermal application of malathion to rabbits have been provided. Data have been provided by the registrant for peak cholinesterase inhibition in rats. In a study in which rats were dosed orally by gavage with malathion for 10 days, it was determined that peak EChE inhibition occurs at approximately 60 minutes. Dermal absorption and subsequent release into the bloodstream are expected to be slower than through oral ingestion and coupled with the oral EChE effect levels being slightly elevated relative to the oral database (~2.6-fold higher), the database suggests that the impact of serum sampling time for EChE measurement would be minimal.

In consideration of the dose levels causing cholinesterase inhibition in the oral database and the expected decrease in time to cross the dermal barrier, the impact of the time of sampling on EChE inhibition is expected to be minimal.

Due to the unique physiological and biochemical characteristics of rabbits, the results of dermal toxicity studies in rabbits have the potential to underestimate the toxicity of organophosphates and are not typically accepted by the PMRA. The blood of rabbits has a high level of arylesterases relative to both rats and humans. Arylesterases are key enzymes involved in the breakdown of S=organophosphates and serum arylesterases may break down these chemicals prior to activation by the liver following dermal exposure. However, in the case of malathion, carboxylesterase enzymes are believed more likely to be the dominant enzyme in the detoxification of malathion and malaoxon.

Evidence of this includes:

- i) The high levels of carboxylesterase degrade products in the urine (>80%)
- ii) The similarity of acute subcutaneous LD50s in the rat and the rabbit despite rabbits have substantially higher serum arylesterase activity than rats (Brealey, 1979; ChemID, 2008; Costa et al., 1990).
- iii) An increase in oral LD50 of over 100x following the inhibition of carboxylesterase in rats (Murphy et al., 1959; Dauteran and Main, 1966)

In contrast to the rat and dog oral studies, rabbits exposed via the dermal route up to 1000 mg/kg bw/day for 21 days exhibited no systemic effects of toxicity other than cholinesterase inhibition. Dermal toxicity studies in a species other than rabbit were not provided. A comparison of dermal absorption between rats and rabbits suggests that rabbits have a substantially greater capacity for the dermal absorption of malathion (Dary et al., 1994; Dary et al., 2001; Saleh et al., 1997; Shah and Guthrie, 1976; Wester and Noonan, 1980).

In the recently conducted 21-day dermal study in rabbits, erythrocyte cholinesterase was the endpoint of concern with a LOAEL of 75 mg/kg bw/day (No NOAEL established) being established for males and a NOAEL of 100 mg/kg bw/day (LOAEL 150 mg/kg bw/day) for females. A benchmark dose analysis for EChE established a BMDL₂₀ of 106.7 mg/kg bw/day for both sexes combined. As the most conservative point of departure, 106.7 mg/kg bw/day is now proposed (with accompanying factors) for use in the short and intermediate dermal risk assessment for children's exposure.

There remains concern for the unborn child as evidenced by the developmental toxicity study in rabbits. In this study, an increase in resorptions was observed at the LOAEL of 50 mg/kg bw/day. The NOAEL for resorptions was 25 mg/kg bw/day and when combined with appropriate factors, is considered the most conservative endpoint for use in the dermal risk assessment. The use of the oral NOAEL for resorptions is considered appropriate for use in the dermal risk assessment for adults since a developmental toxicity study in which malathion is applied by the dermal route is not available.

- 1.2b The registrant specifically contested the PMRA's use of the increased incidence of resorptions to establish the short and intermediate dermal risk assessment.

Response

The PMRA's short and intermediate dermal risk assessment for adults used a developmental toxicity study in which pregnant rabbits were exposed orally to malathion by gavage during days 6-18 of gestation. PMRA determined the maternal NOAEL to be 25 mg/kg bw/day based on an increased number of does with resorptions at the LOAEL of 50 mg/kg bw/day. The registrant does not agree that an increase in resorptions occurred in the rabbit developmental study. Furthermore, they contend that if this endpoint is to be used for risk assessment, the appropriate NOAEL for this effect is 35 mg/kg bw/day derived from the DNT study.

Table 2 outlines the values for resorptions as observed in the developmental assay. At 50 mg/kg bw/day, there was a notable increase in does with resorptions, mean resorption sites per doe and percent resorption sites per doe. While these effects were slightly more pronounced at the mid-compared to the high-dose, increases in the listed reproductive parameters were also observed in the latter.

Table 2 Select Reproductive Data from the Developmental Toxicity Study in NZW Rabbits

Dose Group	Dose (mg/kg bw/day)			
	Control	25	50	100
Does with Resorptions	7/16 (44%)	7/14 (50%)	11/13 (85%)	10/14 (71%)
Does Aborted	0/16	0/14	1/14	2/16
Mean Resorption Sites per Doe	0.9±1.2	0.7±1.1	2.3±2.8	2.0±2.7
% Resorptions Sites per Doe	15.6% ±26.9	12.3% ±20.7	29.2% ±34.2	28.4% ±34.9
Corrected BWG	0.23±0.22	0.20±0.19	0.14±0.16	0.11±0.21

Conducting Laboratory Historical Control Data for Resorptions in Rabbit Teratology Studies

Does with Resorptions: not available

Mean Resorptions per doe: 1.18 (range not available)

% Resorption sites per doe: 1.18 mean resorptions per doe/7.51 mean implants per doe= 15.7%

The registrant submitted a consultant's report to support their contention that malathion did not affect resorptions. The consultant indicates that the percentage of total resorptions was within the historical control range of data compiled by the Middle Atlantic Reproduction and Teratology Association (MARTA). While PMRA recognizes the MARTA database as a useful source of information, it is of limited value in this instance since the data are obtained from voluntary submissions from a variety of laboratories. It is well known that the reproductive indices of rabbits are sensitive to a variety of stressors that change with time and laboratory, including such critical factors as husbandry and environmental conditions. Therefore, wide variations in historical values would not only reflect a natural tendency for variation, but also the variable

quality of submitted data and variability introduced by a myriad of other factors. Comparison of the test data (as provided in Table 1) with conducting laboratory historical data still suggests an increase in resorptions at the mid- and high-dose. There were no other acceptable studies available in which reproductive endpoints were examined in rabbits.

The registrant suggests that there was no evidence of increased resorptions when results are combined with the range-finding study. The PMRA notes that interpretation of the range-finding study is limited due to the small group size used (2-4 females per group) and that findings in two of the three higher dose levels (200 and 400 mg/kg bw/day) were compromised by a high incidence of mortality in the dams.

Table 3 **Select Reproductive Data from the Range-Finding Developmental Toxicity Study in NZW Rabbits (as provided by registrant)**

Dose Group	Control	Dose (mg/kg bw/day)		
		25	50	100
Does with Resorptions	4/4 (100%)	2/3 (67%)	2/4 (50%)	1/2 (50%)
Mean Resorption Sites per Doe	2	1.7	2.75	2.5
% Resorptions Sites per Doe	33%	42%	28%	29%

NB Animals from the 200 and 400 mg/kg bw/day groups were not included in the table due to excessive mortality.

The PMRA also notes that the rat developmental toxicity study indicated a slight increase in resorptions (77% at 800 mg/kg bw/day compared to 57% in the control animals) at the high dose level with accompanying toxicity to the dams (for example, clinical signs and decreased weight gain)(Table 4).

Table 4 **Dams with Resorptions in the Developmental Toxicity Assay in Crl:CD(SD)(BR) Rats**

Dose Group	Control	Dose (mg/kg bw/day)		
		200	400	800
Dams with Resorptions	12/21 (57%)	14/22 (64%)	12/22 (54%)	17/22 (77%)

Therefore, the PMRA reaffirms that the maternal NOAEL for the rabbit developmental toxicity assay is 25 mg/kg bw/day due to effects at 50 mg/kg bw/day including increased resorptions, increased post-implantation loss and decreased maternal weight gain during the treatment period. It is acknowledged that the registrant is of the belief that a NOAEL of 35 mg/kg bw/day from the rat DNT range-finding study should be used for this endpoint. However, PMRA does not consider it prudent to disregard the inherent differences in species susceptibility to toxicological effects or use a range-finding study in establishing an effect level for use in risk assessment. The PMRA acknowledges that the resorptions are observed in the presence of maternal toxicity (ie. decreased body weight gain during gestation) and may not be observed in the absence of this degree of maternal toxicity.

1.3 Other points contended by the registrant

- 1.3a The registrant contends that the use of gavage dosing studies in the establishing of reference doses may result in overprotective reference doses due to a bolus effect.

Response

While dosing by oral gavage for some organophosphates is believed to result in lower effect levels for cholinesterase inhibition than by dietary administration, there are no comparable studies in the database to support this finding for malathion for either acute or repeat dose scenarios. As well, brief windows of exposure, such as a gavage dose would simulate, are relevant to human exposure patterns, particularly with respect to acute exposure and some dietary consumption patterns. Therefore, registrant assumptions of reduced toxicity under a dietary vs gavage route of exposure would not be protective of the human population and therefore were not considered in the revised assessment.

When considering risk assessment from non-oral routes of exposure, the PMRA prefers to use studies conducted with the most appropriate route and duration of exposure if adequate studies are available and address endpoints of concern. This can be observed in the choice of studies for the establishing of short- and intermediate-term inhalation risk assessments in the current assessment.

- 1.3b The registrant contended that the PMRA has not considered a study conducted using human volunteers.

Response

PMRA does not use toxicity studies for risk assessment in which humans are intentionally dosed with pesticides for identifying a human No Observed Adverse Effect Level. Human studies of this nature that have been brought to the PMRA's attention have been used solely in a supplementary manner to confirm that the animal model is an appropriate surrogate for assessment purposes. The human volunteer study did confirm that the animal species were appropriate surrogates for assessing toxicity in humans (ie. EChE depression was identified in the human volunteer study). This is corroborated by poison control center findings which associate cholinergic symptoms in humans with malathion exposure.

- 1.3c The registrant recommended the addition of effect levels for acute clinical signs to the summary in order to compare with those established for EChE inhibition.

Response

The PMRA concurs with the registrant that the acute clinical signs in the treated animals occur at doses exceeding those eliciting erythrocyte cholinesterase inhibition. PMRA will further elaborate on the effect levels for clinical signs in the current assessment.

- 1.3d The registrant recommended that the PMRA include effect levels that were critical to identifying organs of concern including the liver, thyroid/parathyroid, kidney and the hematopoietic system for the rat and dog bioassays.

Response

The PMRA will aim to further elaborate on the effect levels of discussed endpoints in the revised assessment.

- 1.3 e The registrant disagreed with the statement that erythrocyte cholinesterase was preferentially affected over plasma and brain cholinesterase most of the time, instead claiming that this trend occurs unequivocally in all toxicity studies.

Response

The PMRA has re-reviewed the toxicological database and maintains that erythrocyte cholinesterase is typically affected at lower doses compared to plasma and brain cholinesterase, although this trend is not always consistent between studies.

- 1.3 f The registrant contended that there is no difference in sensitivity to malathion between sexes.

Response

The toxicological database, which includes various oral studies such as the subchronic neurotoxicity study in rats, the comparative cholinesterase study in rat pups and adults, the recently submitted comparative cholinesterase study with malathion/malaoxon, as well as the chronic mouse, rat and dog studies, was re-examined. The weight of evidence does not support a gender difference. PMRA will modify the statement relating to gender differences in the revised assessment.

- 1.3 g The registrant contended that the toxicity of malathion does not increase with the duration of exposure.

Response

The PMRA agrees that studies monitoring effects over time, as well as the cumulative database should be used in determining the effects of duration of exposure upon toxicity. PMRA does not believe an analysis of erythrocyte cholinesterase data over an extended duration of time to be informative due to limitations related to the low rate of resynthesis of erythrocyte acetylcholinesterases over extended periods of time. Following the reexamination of the brain cholinesterase data provided for the chronic toxicity/ oncogenicity rat study, PMRA finds the data to be equivocal with respect to duration of treatment. An increased inhibition of BChE at the two year measurement was noted in the 12000 ppm females compared to other timepoints (37%, 49%, 27% and 67% inhibition compared to controls at 90 days, 180 days, 1-year and 2-years respectively) but not in the 6000 ppm females (17%, 17%, 12% and 18% inhibition compared to controls at 90 days, 180 days, 1-year and 2-years respectively). An increased inhibition of BChE at the two-year measurement was noted in the 6000 ppm males (12%, 12%, 11% and 31% inhibition compared to controls at 90 days, 180 days, 1-year and 2-years respectively) but not in 500 ppm males. While it is recognized that cholinesterase inhibition is a primary endpoint for reference dose consideration, an increase in duration also increases the toxicity of malathion in the kidneys of rats and at higher doses, the hematopoietic system of dogs. Evidence of such is provided by both the comparison of effects between short- and intermediate-term dog studies, the subchronic rat study, as well as the interim and final sacrifices of the chronic studies in rats.

- 1.3 h The registrant was in disagreement with PMRA's interpretation of neuropathological effects.

Response

Interpretation of histopathological findings observed in the acute and subchronic neurotoxicity studies is complicated by the small size of groups necropsied (5 animals/dose group) and the lack of histopathological examination of the low and mid dose groups in both studies.

In the acute neurotoxicity study, pathological examination revealed the presence of a bilateral retinal rosette. While a rare finding, a similar finding of one unilateral retinal formation was observed in the control dose group of the subchronic neurotoxicity assay. Ocular effects were not observed in the chronic/ carcinogenicity assay or other neurotoxicity assays conducted in rats. There is a low degree of concern that this effect is treatment related.

In the acute neurotoxicity assay, high dose males were observed with axonal degeneration of the lumbar root, digestion chambers in the lumbar dorsal root fibers and digestion chambers & axonal degeneration in the sciatic nerve, with each effect being observed in one of the five animals. Necropsy of control animals revealed digestion chambers and axonal degeneration in the sciatic nerve of one male animal. In the high dose males necropsied following the subchronic neurotoxicity study, digestion chambers were again observed in the lumbar dorsal root fibers and the peroneal nerve in one animal, and a second high dose animal was also observed with swollen axons and demyelination of the sciatic nerve. These effects are considered equivocal in nature and are observed at dose levels exceeding those used to establish reference doses. However, recognition of these effects will be maintained in the risk assessment, with a modification to include their equivocal nature in order to provide a more complete toxicological profile.

- 1.3 i The registrant disagreed with PMRA's reference to limited evidence of endocrine effects in animals following exposure to malathion.

Response

A re-review of the data indicates that the current database does not contain sufficient evidence of endocrine disruption to warrant the concern raised. This will be reflected in the revision of the risk assessment.

- 1.3 j The registrant contested PMRA's reference to altered immune response following malathion exposure.

Response

There are many studies in the open literature investigating the potential immunotoxicity of malathion in a variety of species. The experimental systems presented are varied as are many of the findings. However, identified studies have indicated a potential for malathion to alter humoral immunity and cellular immunity function, and therefore alter the host's immunological capacity to handle future challenges. To date, only basic measurements of potential immunological effects have been examined by guideline studies submitted to the PMRA.

Since there remains concern over the potential effects on the immunological system following exposure to malathion, a statement has been included in the revised assessment referring to these potential effects. Currently, no additional uncertainty factors have been used to accommodate this concern as current reference doses are believed to be protective of such endpoints. In order to ensure an adequate hazard profile for malathion, the PMRA is requesting a guideline immunotoxicity assay be conducted and submitted by the registrant.

1.3 k The registrant contested the NOAEL established for the 2-year chronic toxicity/oncogenicity study which was used in the long-term dermal risk assessment.

Response

The PMRA has re-reviewed the data and maintains that an increased severity of chronic nephropathy was observed in female animals exposed to 500ppm malathion in feed. Increases in severity of chronic nephropathy were observed in both sexes in this study, with the males also demonstrating an earlier onset of the disease at interim sacrifice. This increased severity and earlier onset of chronic nephropathy are further linked with treatment to malathion by an increase in mortality related to this condition in males at 6000ppm and females at 12000ppm. PMRA concluded that while increases in relative liver weights occurred in both males and females, the effects were only slight at a dose of 500ppm (26♂/32♀ mg/kg bw/day), increasing more substantially at 6000ppm. Absolute and relative thyroid/parathyroid weights were increased in all male dose groups, although not in a dose-related manner. In females, however, absolute and relative thyroid/parathyroid weights decreased, although again not in a dose-related manner. In light of the lack of dose-response, consistency across sexes and correlating histopathological effects, the effects on thyroid/parathyroid weights are not considered treatment-related. The NOAEL for the study is 100/50ppm (3.0 mg/kg bw/day) based upon an increase in severity of chronic nephropathy at 32 mg/kg bw/day in the female rats.

2.0. Comments Pertaining to Occupational / Residential Exposure

One commenter noted that in a published study conducted by the Institut National de Santé Publique du Québec results are consistent with the hypothesis that the closer we get to the emission source, higher is the concentration of pesticide that an individual is exposed to. This thorough study was conducted considering the maximum malathion application rates written on the label. In regard to those results, the terrestrial application seems more problematic than the aerial application.

Response

The residential exposure and risk assessment in PACR2003-10 was based on the current maximum application rate of malathion for residential areas. This value was based on the rate recommended when vehicles are present, and the typical use pattern of malathion when used in mosquito abatement program. The deposition values of malathion used in the risk assessment are

higher than what was reported in a more recent paper by Mickle *et al.* (2005)¹³. Since acceptable MOE's were obtained for both toddlers and adults following either aerial or ground ULV application, the residential exposure and risk assessment was not revised in the current evaluation.

Comments Pertaining to the Environment:

1.0 Comment on the effect of malathion on fish

The document states that "malathion is highly toxic to fish and invertebrates" but does not clearly state that malathion must not be used in areas where it is likely to enter areas of fish habitat. A stronger statement is required.

Response

The statement "malathion is highly toxic to fish and invertebrates" provides information on the inherent toxicity of the active ingredient. There is no need for a stronger statement as it was followed by other statements in the malathion document that explain the reasons why the impact on aquatic organisms will be limited. In addition, the paragraph ends with a precautionary statement about not to contaminate sensitive aquatic environments.

2.0 Comment on mosquito recolonization

Pg.14 states that "Some individuals of non-target insects and other arthropods, that are present in the residential areas and that are active at spraying times, may be affected, but it is expected that the effects on the populations will not be permanent due to recolonization from rural unsprayed areas." What prevents very mobile mosquitoes from also recolonizing the sprayed areas? If recolonization is as easy as is suggested in the statement above, perhaps spraying with malathion is a waste of resources. If mosquitoes recolonize as well as the missing desired species, then more applications will be required, which will continue to negatively displace both mosquitoes and the desired species. The area will not therefore be recolonized, and the effects on the populations will not be temporary. The validity of this statement should thus be examined.

Response

The use of malathion for large-scale adult mosquito control (such as adulticiding), whether for nuisance or vector control, is considered to be part of an Integrated Pest Management (IPM) approach. Adulticiding is only to be used when warranted, often when source reduction and larviciding measures have not achieved an adequate level of control. Adulticiding should only be viewed as an option if surveillance activities (for example, systematic monitoring of mosquito populations) indicate that certain thresholds have been reached which identify the need to consider implementing mosquito control activities in targeted areas. Because adulticiding would be triggered by surveillance information, the likelihood of numerous applications in a season in Canada is unlikely. In practice, if intervention with malathion as an adulticide was deemed to be

¹³ Mickle, R.E., Rousseau, G., and Samuel, D. February 10, 2005. Direct comparison of Deposit from Aerial and Ground ULV Applications of Malathion with AGDISP Predictions. REMSpC Consulting, 12 Welsh Drive, RR3, Ayr, ON, Canada, N0B 1E0. REMSpC Report 2005-02. Unpublished.

necessary, it would typically be applied no more than 1-3 times per season in Canada, whether for nuisance or vector control.

3.0 Comment on the effect of malathion on aquatic system

Pg.15 states "Spray droplets may evaporate during this period of suspension in the air, and so, not deposit at all. Thus, deposit into aquatic systems from this type of application is reduced, exposure is minimized and adverse effects are, as a result, limited." Evidence to support this statement from referenced scientific literature, and examples should be provided in the document.

Response

The following three papers from the scientific literature provide support to the statement that exposure from ULV sprays is minimized and adverse effects are, as a result, limited.

- 1) Jensen, T. et al. (1999). Effects of ultra-low volume pyrethrin, malathion, and permethrin on nontarget invertebrates, sentinel mosquitoes, and mosquito fish in seasonally impounded wetlands. *Journal of the American Mosquito Control Association* 15(3):330-338.

Jensen et al. (1999) assessed the effects of ULV application of malathion on nontarget invertebrate populations, caged mosquitoes, and mosquito fish (*Gambusia affinis*) in wetlands in California. The ULV application was by truck and the results indicated that ULV applications of malathion could be conducted near wetlands to control mosquitoes without killing fish or substantially reducing the amount of aquatic invertebrates. Some individual taxa of aquatic invertebrates exhibited trends of increasing abundance after treatment, as would be expected with continued reproduction or colonization. In Canada, adult mosquito control to disrupt the transmission of West Nile Virus would be carried out in urban residential areas and in such areas the prevalence of sensitive aquatic ecosystems, such as wetlands, would not be that frequent.

- 2) Tagatz, M.E. et al. 1974. Effects of ground applications of malathion on salt-marsh environments in northwestern Florida. *Mosq. News* 34(3): 309-315.

A field study was conducted to determine the effects of three ULV sprays of malathion at 57 g ai/ha, on salt-marsh environments in Florida. A truck-mounted generator was used for the ULV sprays as in typical mosquito control operations. No mortality of resident crabs, fishes, and shrimps were noted after any treatment. Confined crabs, fish, and shrimp and free-living snails obtained one day after each spray contained no detectable malathion. Malathion was not detected in sediment one or six hours after treatments.

- 3) Tagatz, M.E. and G. R. Plaia. 1985. Effects of ground ULV applications of fenthion on estuarine biota. V. Response of field and laboratory estuarine benthic communities. *J. of the Florida Anti-Mosquito Assoc.* 56(2):76.

The reference provides another example of ULV spray applications when used for control of adult mosquitoes have minimal effects on aquatic non-target organisms. In a study at a salt marsh site in Florida, two ULV ground applications of fenthion for adult mosquito control showed no significant impact. There were no significant differences in the mean numbers of individuals and species between the controls and the communities exposed to fenthion. The abundance of the dominant phyla, annelids (primarily polychaete worms) and arthropods (primarily amphipods and midge larvae) did not differ significantly between control and treated communities.

4.0 Comment on the requirements of additional data

The PMRA document requires additional data to be collected: air concentration and deposition data for both ground and aerial ULV applications under typical use conditions. Measurements of deposition should include deposits of malathion onto pond surfaces and the concentrations in shallow water of ponds in residential areas. When those data become available, it should be possible to calculate potential concentrations in aquatic habitat where amphibians and invertebrates could be affected.

Response

In the future, if there would be some ULV ground and/or ULV aerial applications of malathion for control of adult mosquitoes to protect the public against West Nile Virus, consideration will be given to collection of data on air concentrations and deposition data in aquatic environments in residential areas. Environment Canada would be approached if it could be done under their research and monitoring mandate. The PMRA has included malathion in the list of pesticides for water surveillance/monitoring program.

Comments Pertaining to Value

1.0 Comments on efficacy

Concern that the Canadian rate reduction of the aerial ULV application rate to 260 g ai/ha from 496.6-642.7 g a.i./ha as a result of harmonization with the USA will result in loss of efficacy.

Response

The registered label rate range for aerial ULV application of malathion for the control of mosquitoes is 234 to 643 g ai/ha. The proposed aerial application rate of 260 g ai/ha falls within the registered effective range.

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